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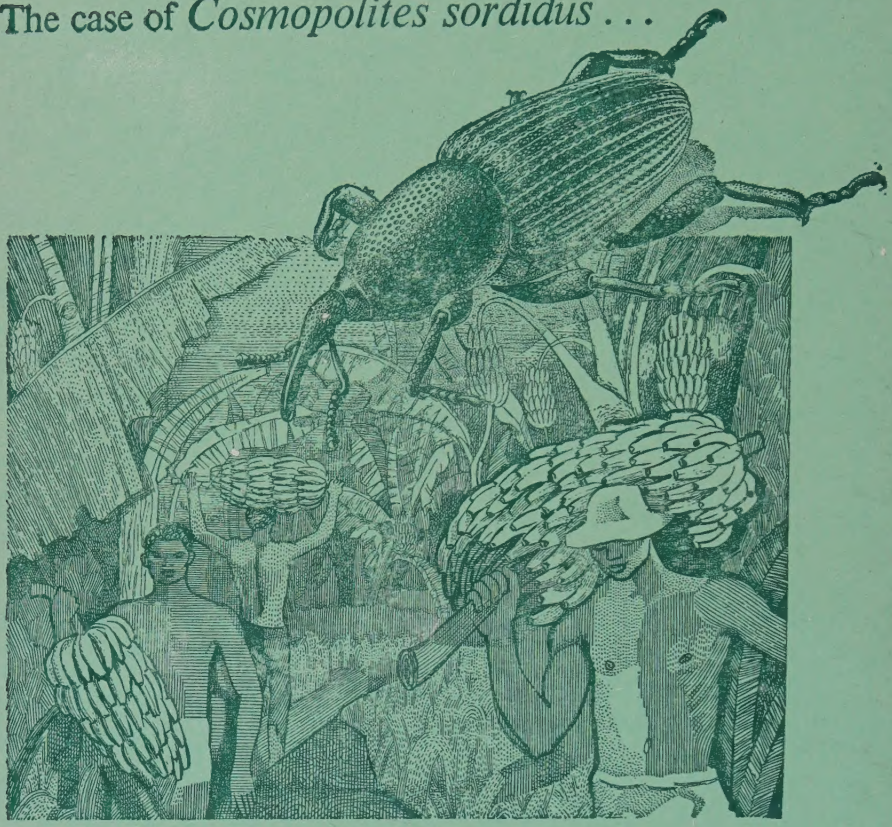
The case of *Cosmopolites sordidus* . . .



Bananas are one of Cuba's basic harvests, yet few of the plantations have at some time or another escaped the destructive attentions of the banana root borer, *C. sordidus*.

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Agriculture and Forestry

W. A. Gordon
Imperial Forestry Institute, Oxford

It is unusual to find the problems of forester and agriculturist so identified that the layman can follow the connection. However, this identification has become only too apparent in some of the arid and semi-arid regions of the world and particularly in those that have come to be recognized as man-made deserts. When cultivators are reduced to using their only source of fertilizer in the form of dried dung for fuel, when no fruit tree is safe from the depredations of the fuel merchant and when every further removal of natural growth is an obvious victory for the desert, the separation of agricultural and forestry problems becomes quite difficult.

It is at the other extreme, in the early days of development in a tropical territory, that foresters and agriculturists rarely seem to meet. Their meetings become more frequent as land ceases to be an unlimited commodity and there is a strong tendency for their attitude to develop along competitive rather than cooperative lines. To agriculturists, foresters commonly appear as selfish people sitting on potentially cultivable land which could provide a better cash return under agricultural crops. To the forester, agriculturists are people to be carefully watched as a possible danger to the security of the forest estate.

During the early and extensive phases of forest management the question is often asked: What are the foresters doing ? They disappear for long periods into the jungle and, since foresters as a race are apt to be unduly reticent about their activities, the reasons for their absences are not always made clear. During this phase the answer usually would be that they are finding out what grows in the country and where it is to be found and are staking out claims to such areas as in their opinion ought to be preserved as part of the permanent forest estate. In this latter respect foresters almost always find themselves obliged to work well in advance of any general land planning arranged at a national level; frequently having been obliged to work in advance even of the preparation of proper maps. Land planning at a national level is rarely thought of in the earlier stages of development in a new country; it rarely presents itself until cultivable land is at a premium and until land administration generally has become so disorganized as to attract the attention of the central government and the public. On the other hand, experience has shown that long before this stage is reached forest devastation, if left unchecked, is likely to reach a point from which subsequent recovery is difficult. If foresters were to wait for national land planning before staking out their claim, they would usually find themselves with a legacy of bare land which they would possibly have to buy at some absurd notional valuation after it had fallen into individual freehold ownership. To illustrate this it is not necessary to look any further than England.

About a thousand years ago in England under the forest laws then in force the reservation was achieved of a considerable forest estate. It was,

of course, too small for the eventual needs of the nation and, not surprisingly, it was badly selected. The objects of management did not include timber production and the emphasis was always on hunting. Consequently it had public opinion against it and therefore dwindled until a mere hundred thousand acres, and much of that bare of trees, remained available for the national forestry development programme of this century. The balance of the millions of acres required for our national needs must now be purchased for its full market value and replanted. This is an expensive way of building up a national forest estate.

If the early Norman kings, to suppose something most unlikely, had had a competent forest service, the millions of acres necessary for the present programme could have been acquired more or less free of cost and, if properly selected, would have coincided roughly with the area now being purchased and replanted. If properly maintained during the centuries it would probably have been retained and would have saved much of the cost of imports over several hundred years, most of the embarrassment over timber supplies in two world wars and the very heavy cost falling on the present generation for the re-afforestation of impoverished land. Against these last advantages the most that can be set is the extensive use made of this land as unimproved pasture and moor and perhaps a cash return into the pockets of the people who felled the timber off it some centuries ago.

If comprehensive land classification and land planning could be achieved in the pioneer stage of the development of a country, nobody would welcome it more than the forester. Even where it meant that land that he wanted became earmarked for other uses, this would usually be a small price to pay for the assurance at an early stage that land dedicated to forestry would be dedicated permanently and that money and effort spent on achieving planned forest management would not be wasted on a subsequent change of land use. The first aim of every forest service must be a permanent forest estate, secure against population pressure and ill-advised administrative decisions.

As it is, the forester has usually had to make his own land-planning decisions and had to try to foresee the future trend of agricultural development, often in country that was unpopulated at the time. He does not want to take in land that is suitable for settled agriculture except insofar as this may be necessary for the rounding off of boundaries. What is required is land that can be retained and which is obtainable for a low price.

His mistakes will be shown up with the growth of land shortage as the competition between forestry and agriculture begins. If through error or misjudgment land is taken in that could be put to better use under settled agriculture and if the agricultural production is required at once, there may be no case for keeping it under forest. The forester dislikes having to surrender land for spendthrift kinds of agriculture which may not be permanent, when the country is full of half-used land elsewhere, or surrendering land of low agricultural value merely because it is more accessible and convenient than more fertile land further away. The argument that food is more valuable and more important than wood has led to much deforestation but ought only to carry full weight if the same things are being compared —sustained yield under managed forest against static residential agriculture

with the minimum of unproductive fallow, or against stock farming on improved pastures. Even then the comparison is not always reliable: the annual yield of an acre may be much more valuable in the form of corn than wood when both are in adequate supply on the spot, but not necessarily if most of the wood has to come from distant sources. In parts of the Middle East for instance, during the cold winters of 1948–49 the difference in price between a ton of potatoes and a ton of wood fuel became surprisingly small.

Pressure on the forest estate is apt to begin when the first signs of land shortage are present; as soon as the forest land is wanted to perpetuate the customary practice of shifting cultivation, or as soon as access to the forest is required to relieve the agricultural land of surplus livestock. It is not denied that under certain conditions forest grazing can be tolerated. There are also ways and means of using shifting cultivation as a cheap method of establishing forest plantations.

THE TAUNGYA SYSTEM

The *Taungya* system was devised by foresters for the benefit of foresters and as thus applied is more suited to migratory forms of shifting cultivation than to the more static bush fallow. The cultivator under conditions of land shortage is glad to take advantage of the chance to farm an area of logged-out forest. The forester on the other hand is pleased to have the land cleared for him and kept free of weeds for two years or so while his plantation becomes established. The cultivator grows his food crops for two or three years until the plantation trees begin to form a canopy and then moves on to another area. Under the *Taungya* system as practised by foresters the forest crop is the first consideration and the agricultural yield is secondary. Although it may be possible, for instance with plantations of fast grown tropical pines, to repeat the process at regular and fairly short intervals, the interval is determined by the rotation of the forest crop and is not likely to be less than thirty years. On the other hand it is not difficult to imagine such a system being applied by agriculturists and foresters in cooperation, with the agricultural crop having the priority and the forest crop performing the role of a productive fallow to provide small material on a short rotation for local use.

To that extent at least dual use of land may be possible and forestry and agriculture can overlap. The considerations are quite different when a permanent and perhaps an irreversible change of land use is proposed. Projects of this nature should be approached by foresters and agriculturists as allies rather than competitors and it will often be found that their interests and conclusions are very similar. During the earlier phases of extensive land use in an undeveloped country, the agriculturist is as much at sea as the forester. Since both land and forest produce are apparently available in unlimited quantities, it is difficult to persuade the people or the government that these are both articles of value which should not be wasted. Just as it is bad forestry to devastate the natural woodlands of a country and then have to reclaim and replant when wood shortage makes itself felt, so it is bad agriculture to allow the extensive phase to carry on for too long until all the land has been half-used and much of it has been spoilt. In broad outline the objectives of the forester and agriculturist are the same,

to keep all the land fully productive and by the scientific application of increased work to raise the production per unit area.

Just as the forester cannot get a hearing while supplies of growing timber, which has cost nothing to produce, are apparently unlimited so the agriculturist has a poor chance of leading a trend towards settled residential agriculture where virgin land which will yield a crop or two with the minimum of work is to be had for the trouble of clearing it. It has yet to be proved that governments can be induced to adopt a whole-hearted policy of forest conservation until devastation has given a scarcity value to such forest as has survived. It has also to be proved that administrators will face unpopularity by sanctioning measures to induce the intensification of agricultural land use until shortage of land has brought the extensive methods to a natural halt.

By staking his claim to an area of forest sufficient for national requirements the forester commonly renders an unintentional service to the agriculturist. By bringing migratory cultivation to a halt, he enforces more static systems at an earlier stage than would have happened in the normal course of evolution. Migratory cultivation gives way to the more settled bush fallow and provides the agriculturist with something to work on. Although there are few records of tropical cultivators having taken to static agriculture until obliged to, there are also few records of the reverse process. Once a community of shifting cultivators has settled it does not readily start moving again. The greater comfort and the amenities of a static existence are sufficient consolation for the additional work which static agriculture requires and the acquisition of more bulky property and the introduction of perennial cash crops makes the prospect of moving unattractive. The Gold Coast affords a good example of shifting cultivation giving way to static agriculture in a period of less than a hundred years, and forest reservation has played its part together with cocoa.

FREE RANGE GRAZING

Similar arguments apply in the case of stock farming. The interests of forester and agriculturist although sometimes apparently at variance are in reality quite closely identified. They are at variance in so far as in the earlier stages the agriculturist may be anxious to free cultivable land from the burden of free range cattle and, while the forester may be prepared to cooperate by allowing limited forest grazing, it is rarely to the advantage of either that it should become a regular practice. Even if the damage to the forests is ignored, the mere presence of unimproved pastures where stock can be free ranged is in itself an impediment to agricultural plans. Where the cattleman with the minimum of work and investment can raise a subsistence livelihood from migratory grazing in forest country, he is unlikely to turn his mind to pasture improvement, stall feeding, breed improvement or any other advice which the agriculturist may offer. On the other hand, once free range grazing is prohibited and a more static form of stock rearing is enforced, the stock farmer rarely regrets the free range existence.

It is, of course, only in the last two hundred years that Europe has grown out of the free range habit. The end of free range grazing in England

came only with the Parliamentary enclosures of common land. To take a more recent example, stock rearing in Cyprus, as in the rest of the Middle East, was until recently run entirely on a free range economy. It was superimposed on the farming practice of the country whether the cultivator wanted it or not. Forest grazing was the solution advocated by agriculturists and administrators to relieve the over-burdened cultivable lands. This was resisted by the foresters and in the outcome the forests were closed to grazing. Free range grazing is now nearly ended. Pasture improvement, stall feeding and breed improvement have become standard and, even in the unlikely event of the forests being opened again to grazing, it is doubtful if many would take advantage of what has now come to be regarded as a precarious, uncomfortable and outdated mode of livelihood. Thus foresters and agriculturists have both attained their ends but if only they could have seen eye to eye a generation ago there is no reason why it should not have happened then.

There are many other arguments in favour of an earlier liaison between foresters and agriculturists, in order to understand and integrate each other's aims, instead of waiting until they are forced together to unravel some impossible confusion. There is little political and administrative interference that could stand up to two Departments, of Agriculture and of Forestry, working in agreement with a common policy. On the other hand politicians and administrators thrive on disagreements between technical experts and over land use affairs it is such disagreements which have so often led to their having the last word on matters which they do not understand. As foresters well know to their cost, the easiest solution for a harassed administrator in the face of apparent land shortage is the release of forest land for shifting cultivation and free range grazing. In so far as this perpetuates a wasteful system of land use with no compensating advantage other than postponement of the evil day, it is as much against the interest of agricultural advisers as it is against foresters', for while these systems with their easy subsistence returns are encouraged, agricultural recommendations go unheard.

(*Received March 1956*)

A System of Provision of Credit for African Farmers in Uganda

W. H. Spall

Manager, Uganda Credit and Savings Bank

The Uganda Credit and Savings Bank was established by ordinance in 1950 to assist in providing credit to Africans throughout the Protectorate who, by reason of the type of security they can offer and the type of loan which they require, cannot obtain financial assistance from commercial institutions. Government provided the capital amounting to approximately £600,000, and the original ordinance envisaged that this would commence to be repaid after the first seven years. After four years of operation it became obvious that the bank would not be able to repay its capital and the ordinance was amended by deleting the provision for repayment and permitting a rate of interest to be charged which shall be decided by the Governor in Council. The Governor has decided that for five years from 1954 no interest shall be payable.

The ordinance allows loans to be granted for a variety of purposes, for example agriculture, shopkeeping and trade, business or industry, for the erection and repair of commercial and residential buildings and the purchase of motor lorries and omnibuses. By far the largest number of loans outstanding are for agricultural purposes, and this article will be confined to explaining how the bank works in relation to the farming community.

METHOD OF APPLICATION

I should like to mention the African Loans Fund, for which the bank acts as agent before explaining the method by which applications for loans are considered. By 1953 it became apparent to the Board of Management of the bank that people outside the province of Buganda were being penalized in regard to the issue of loans because of the peculiar land tenure system obtaining in the other provinces. The early experience of the bank showed that loans must be secured; the obvious method was by a legal mortgage over land. This was possible in Buganda where freeholds exist, but not in the other provinces. Government therefore decided to establish the African Loans Fund, which enables loans to be granted on the minimum of security provided the integrity and trustworthiness of applicants are vouched for by committees set up in each area. In addition the African local government of the area in which an applicant resides or carries on business is required to guarantee the repayment of 50 per cent of the outstanding balance of the loan should default occur. I shall explain the working of this fund later.

The Uganda Credit and Savings Bank is governed by a board of management consisting of the Minister of Finance or his representative, who is chairman of the board, the Minister for Local Government or his representa-

tive, and not more than twelve other members, who are appointed by the Governor, of whom no fewer than four shall be Africans. Within the framework of the ordinance the board of management has complete control of the bank's affairs.

When an African wishes to raise a loan from bank funds an application form must be obtained, completed and returned. This form gives full and precise details of the purpose for which the loan is required, and also states what security can be offered. In addition personal particulars are required with special reference to the sources and amounts of the applicant's income. The latter is of vital importance when assessing whether an intending borrower will be in a position to repay the loan within a given period. In the case of agricultural loans the applicant must state precisely how the loan will be used, and is asked to provide some kind of development plan.

Arrangements are then made for the applicant and his estates to be visited by an inspector. These inspectors are Africans employed by the bank for that purpose only. Experience has shown that a system of inspection is of paramount importance and no loans are now granted unless an inspection has been made. Originally inspectors were not employed and loans were made on the information supplied by applicants. It soon became apparent from the number of borrowers who defaulted in the repayment of their instalments and interest that many doubtful debts were being incurred by reason of misleading and sometimes false statements. It also became known that many borrowers were misapplying loans. For example, loans given for agricultural purposes were being used to buy second-hand motor cars. The borrowers felt perfectly safe because they knew that no one would visit them to check the truth of their statements or the manner in which they were using the loan, although in the ordinance there is a penal clause which permits the prosecution of persons who make false statements or who use loans other than for the purposes authorized by the bank.

Since the inspection system was instituted the number of defaulters has decreased rapidly. It has meant that fewer loans have been issued.

The inspectors not only value the land and comment on the standard of cultivation, but endeavour to assess an applicant's trustworthiness and the economics of the project for which the money is required. It must be emphasized that although the inspectors are employees of the bank they do not inspect with the sole idea of criticising the applicant, but also to offer useful suggestions and advice on the improvement of cultivation systems or the better use of the loan, and many borrowers have benefited materially from such advice. Once a loan has been granted it is the duty of the inspectors to 'follow up' and again offer advice and assistance if this is required, as well as ensuring that the loan is being correctly used. The importance of the inspection system cannot be over-emphasized, and as the bank establishes branch offices up-country, an inspector is being stationed at each one.

To return to the consideration of applications, when the inspector's report has been received the application is once again considered by the manager, who makes his recommendations regarding its granting or rejection. He not only takes into account the information given on the

application form and by the inspector but takes particular notice of whether the applicant has had a previous loan or has submitted other applications, and whether in the case of a previous loan, the record of repayment is good. In order to relieve the sub-committees of a great deal of work the manager is empowered to reject those applications which, in his opinion, are obvious ' non-starters ' with the *proviso* that if his decision is appealed against, the matter must be referred to the appropriate sub-committee.

The sub-committees have been set up by the board of management, and have power to grant loans up to certain limits or to reject unsuitable applications. Loans in excess of the discretionary powers of the sub-committee or those involving matters of principle, are referred to the full board for consideration with the committee's recommendations. The agricultural sub-committee consists of board members and co-opted members from the Department of Agriculture and the Registrar of Titles Department, who can offer advice on the projects under consideration and on land values. This system has worked well and enables applications to be handled with the minimum of delay.

Once applications have been approved by either the sub-committee or the board, the bank's staff takes over the administration of the loan and subsequent reports are only made to the committee or the board if the applicant defaults in repayment or an inspection report reveals that the money is being incorrectly used.

PROBLEMS AND THEIR SOLUTION

Some of the problems which confront the committee when applications are being considered are worthy of notice. First, the security and its value must be considered from a banking point of view and in this respect it must be borne in mind that in case of realization the bank can only rely on the ' forced sale ' value of the security taken. It is extremely difficult to explain this to applicants who have little or no knowledge of financial matters. It must also be realized that the valuation of land as security presents considerable difficulty because the land tenure system obtaining in Buganda permits the sale of land to Africans only. In other provinces the land is held under customary tenure and cannot be sold at all. The bank has therefore been compelled to adopt a somewhat conservative outlook, particularly in view of the experience gained in trying to sell land by auction to recover unpaid loans. Another point which must be borne in mind is that although many applicants have adequate security often involving several hundred acres of land, their ability to repay a large loan is doubtful. Here the inspection report is of great value. Many applicants completely overlook the problem of repayment. They see only the money in hand and when it is explained to them how much they will have to repay each year they are quite appalled and frankly admit it is beyond their capability to do so. The bank feels that it is one of its duties to protect applicants against themselves where necessary, and loans are not granted unless, on the evidence available, there is at least a reasonable chance of repayment.

It has become necessary to restrict agricultural loans to the development of the land offered as security. This step has been necessitated because it has been found that if a person is developing the land and living on it he is

less likely to default as he knows only too well that in such an event the land will be sold and he will lose his home and the effort he has put into the development. In several instances where undeveloped land has been taken as security borrowers have made no effort to repay the loans because they considered that the amount which they received represented a reasonable sale price as far as they were concerned without the legal trouble involved in land sales. The bank was then faced with the unenviable task of disposing of uncultivated and often unwanted land.

I have stressed the point of security, and the development of land offered as security, because it must be realized that the bank is dealing with several hundreds of peasant farmers and that this is their first experience of credit facilities. The farmers must be taught that a loan is not a gift and that having entered into certain obligations they must fulfil them. It is a gradual system of education and results so far tend to show that a greater awareness of the obligations imposed by accepting credit is becoming apparent.

There is no doubt that loans which are properly used can, and have, materially assisted many small farmers to improve and expand their farms. The Department of Agriculture cooperates whole-heartedly and the advice of its officers is always available to applicants and borrowers. The bank knows only too well that farming is a somewhat hazardous business and if a borrower gets into trouble through no fault of his own he will find that an approach to the bank will receive every sympathy, and efforts will be made to extricate him from his difficulties. If necessary the period of repayment will be lengthened. It has been difficult to convince borrowers that they should come and explain their problems. Many of them have said that they consider they will lose face if they have to admit their inability to repay although the reasons for not repaying may be quite genuine. It is, however, being more widely realized that the bank does exist to assist trustworthy people, and evidence of this is found in the increasing number of people who seek interviews with the officers and inspectors.

Before going on to discuss the African Loans Fund I should like to make it quite clear that the rates of interest charged are kept as low as possible. It is not the object of the bank to make large profits. As long as overhead expenses can be covered and the necessary reserves created that is considered sufficient. In an effort to encourage borrowers to repay on time a rebate of $\frac{1}{2}$ per cent is given if payment is made within seven days of the due date, and all borrowers are advised well in advance of exactly how much they will have to pay and when.

AFRICAN LOANS FUND

The African Loans Fund, of which mention has already been made, was established by ordinance in 1954 to assist those Africans who are worthy of financial assistance but who yet have no security to offer, or security which cannot be accepted by the Credit and Savings Bank even under its somewhat elastic terms. Government therefore provided £150,000 and appointed the Credit and Savings Bank to act as agent for the administration of the fund. This was done as it was considered that the bank already had the necessary organization and experience and that it would be less expensive to pay the bank an agency fee for the work carried out than to establish a completely

new organization. This arrangement has worked most satisfactorily up to the present.

The board of the bank are not responsible for the granting of loans. A control committee was set up under the ordinance, constituted as follows: two persons employed in the public service of the Protectorate, one of whom shall be nominated as chairman, who shall be appointed by the Governor in council, the Secretary to the Board of the Bank, and four Africans, one representing each province, who shall be appointed by the Governor in council. This committee authorizes loans and drafts the general principles for the administration of the fund by the agent.

The real security upon which loans are made from this fund is the integrity and credit-worthiness of the borrower. It is obviously impossible for the control committee sitting in Kampala to have knowledge of the thousands of applicants who apply for loans. Area committees have therefore been established at all district headquarters. The duty of these area committees is to examine all applications, and add their recommendations as to the fate of each. The control committee is not, however, bound to accept the area committees' recommendations. It is emphasized that area committees cannot grant loans or reject applications, but act only in an advisory capacity.

It was considered that under present conditions it was necessary for the African local government having jurisdiction in the area in which the applicants reside or carry on business, to demonstrate their faith in the local recommendations by occasionally guaranteeing 50 per cent of any loan outstanding. Needless to say the African local government has a substantial representation on each area committee.

The method of examining and deciding the fate of applications is very similar to the method previously described for applications for loans from bank funds, excepting that this is carried out by the control committee and not by a sub-committee of the board of the bank. The provisions for prosecution in the case of false information or misuse of loans are also similar.

The African Loans Fund opened for the receipt of applications on 3 January 1955, but it soon became apparent from the rate at which applications were being received that if the fund was to be successful it would be necessary for 'on the spot administration' to take place, particularly if borrowers were to be trained in the proper use of credit and made to realize that loans must be repaid on the due dates. The provincial administration indicated that they would be quite unable to undertake this task for two reasons, first, that their staff was fully occupied with other duties and secondly, that their staff was not trained in banking business. Under the circumstances the control committee of the fund requested the Credit and Savings Bank to open branch offices up-country to assist in the close administration of the moneys lent, and they agreed to reimburse the bank for the expenses incurred in establishing and running these branch offices in accordance with the amount of work done for the fund. The bank acceded to this request and three branch offices are now open. Recruitment is proceeding for additional staff and if this is forthcoming the bank proposes to open three more branch offices within the next twelve months.

In those places where the branch offices have been established the officer in charge acts as secretary to the area committee and an inspector is stationed

at each branch. Here again the importance of the inspection system must be stressed. Applications received through the branch offices are accompanied by full reports and the control committee is able to reach a decision without having to refer back to the area committees. In this way much correspondence is avoided and successful applicants can be granted loans with the minimum of delay. It is also known in those districts that the inspectors will ' follow up ' loans to see that they are being properly used and it may be of interest to note that at the time of writing the first instalments on loans granted earlier in the year have fallen due and that in those places where there are branch offices and inspectors no default has so far occurred. This cannot, unfortunately, be said of other districts.

It is as yet too early to say whether the major number of loans from this fund will be granted for agricultural purposes but the indications are that a very substantial number will be. Unfortunately the Buganda Government have not yet agreed to give the necessary guarantee as to the repayment of 50 per cent of loans granted and it is with reluctance therefore that the control committee have had to say that the Baganda cannot participate in the fund until such time as the guarantee is forthcoming.

These are broadly the principles on which loans are made both from bank funds and from the African Loans Fund, and although this article is concerned with the subject of the provision of credit reference should be made to the savings side of the bank's activities.

The savings bank section has expanded most encouragingly, this expansion continues, and it is hoped that it will increase with the establishment of more branch offices. The people who have loans are encouraged to open savings bank accounts and pay in their surplus cash. If they do this it means that when their instalments become due for repayment the money is available and an easy transfer can be made from one account to the other. It also enables the borrower to take advantage of the $\frac{1}{2}$ per cent rebate given for time payment. His savings also earn $2\frac{1}{2}$ per cent per annum interest and so it may well be that a prudent and provident borrower can borrow for as little as 2 per cent. I am convinced that with a credit system in operation it is of equal importance to encourage thrift if the peasant farmer is to be taught the proper use of money.

(*Received December 1955*)

Mechanization of Rice Production

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Rice is stated to be the world's oldest crop. No crop of major importance can show older techniques still in use and such a wide variation in the methods employed in its production.

The manpower requirement per acre varies upwards from two days for the well mechanized areas of the United States, with a world average of about 200 days per acre, and in some areas this will increase to something over 400 man-days per acre. These differences in labour requirement have been produced by mechanization. The contrasting extremes in mechanization between the Californian or Texas farmer, ploughing 25 to 30 acres in a 10-hour day, or up to 70 or 80 acres with his tractor fitted with headlights, high clearance tyres and wheels, cushion seat, heater and radio, and the Japanese rice grower who prepares his land by hand labour with an output of not more than 1/5 of an acre per day, have between them a whole range of different methods of cultivation including the 5-horse hitch of the Argentine, where the farmer sits on his ' riding plough ' to turn over his soil at 8 to 10 acres per day, and the Indian farmer with his pair of bullocks and a wooden stick, occasionally with a metal tip, which is the local form of plough.

The variations carried on throughout all the rice growing operations, include the Californian rice producer who uses an aircraft and with the assistance of two neighbours as ' flag men ', will seed up to 400 acres in a day. In the upper reaches of the Amazon, the Brazilian peasant walks across a freshly burned area of jungle, makes small holes with a stick in the ashes of the fire at irregular intervals and puts a few seeds in each. After covering the seeds by scraping some soil over them with his foot, he will forget about the crop until it is time to harvest the produce.

Meticulous care is used in the preparation of the seed-bed in Siam, China and India. After careful preparation of the soil, all the available ashes from the fire and any surplus manure and mud are spread in a layer to make a fine rich top-soil in which the seeds are broadcast by hand. After 35 to 40 days the seedlings are pulled by hand for transplanting in other fields which have been prepared in the meantime. This almost universal method of transplanting can be contrasted with the mechanical rice transplanter which is now a *fait accompli* in Northern Italy.

Use of fertilizer also presents some contrasts. The American farmer is content with between 100 to 200 lb. of sulphate of ammonia. The farmers of India, Malaya and Ceylon are content either to apply no artificial fertilizer, or to use it very sparingly. The Japanese farmer on the other hand, realizing the importance of high production from his very limited area, would not consider himself doing justice to the crop if he applies less than 500 lb. of

fertilizer per acre during the growing season. The range of contrasts can be extended to show similar differences when irrigation, harvesting, threshing, milling and transport are considered; but sufficient has been written to emphasize the great difficulties in applying any uniform method of mechanization to this vast and all-important industry.

That rice is the most important agricultural commodity cannot be denied. It is the staple food of three fifths of the world's population and it is a food from which the user, being reared on it as the main item of his diet, is very reluctant to change. Surpluses of wheat and other grains in the world will never be the answer to hunger among the rice-eating people.

Every endeavour must be made to increase the production of rice and reduce the cost of production. The responsibility for this lies with all sections of the agricultural industry. The agricultural machinery manufacturer has a responsibility equal to that of the plant breeder, soil physicist, entomologist, fertilizer manufacturer and educationalist. All must play their part in production of this necessary commodity, and it is pleasing to note that from the agricultural engineering industry we have observed a real desire for close co-operation by development of new varieties, new methods of cultivation, of weed and insect control, of harvesting, and vigorous education schemes to ensure that this ' land of plenty ' will give of abundance by proper treatment.

This article deals only with the mechanization aspect and even such a treatment can only be rather scanty, for the application of machines to rice growing is a new science, or rather an old science to which a new approach is being applied. Land preparation is easy with existing equipment where the grower has full control of the water supply. If the land is too hard a few inches of water can be run on, allowed to soak into the sun-baked soil, and using a tractor, plough and cultivator, which will be found on any European mixed farm, the soil can be prepared and left ready for re-flooding before transplanting.

Such fortunate farmers are, however, in the minority. Most growers will have to prepare their land at a set time without the aid of water control. Where land is very hard the mounted disc plough, or in some cases, the mounted mouldboard plough will be found very useful. Use of disc harrows, preferably the mounted easily manoeuvrable type, and tillers or cultivators, to break down the soil, will enable the farmer to operate mechanically and faster, thereby making his land ready to receive the transplant seedlings as soon as the rains come or water is available.

Other contrasting conditions where the grower always has water on his land, *e.g.* irrigated areas where two or three crops of rice are harvested each year, require different treatment, and the recent introduction of a special mounted disc harrow on the Ferguson tractor is proving of considerable advantage in time and cost of preparing the land (see *Figure 1*). This combination also uses the extension cage wheels fitted to the rear tyres. The cage wheels provide additional traction and the rubber tyres reduce almost to a minimum any tendency for the tractor rear wheels to dig themselves in. The disc harrow has been built as light as possible so that it may be lifted on the hydraulic system of the tractor. When working in trashy

conditions, or when incorporating green manure in the soil, the discs will float over the trash to force it into the soil.

Heavy discs dig too deeply and in trashy conditions the cutting edge of the disc becomes almost at right angles with the soil, so that the trash builds up in front of the harrows. An article written as a result of special tests carried out in Malaya erroneously concludes that disc harrows are not suitable for rice land preparation.

The light disc harrows referred to above, mounted on the hydraulic

Figure 1. Land preparation: the scalloped discs incorporate a heavy top growth very successfully

system, ride easily over any trash. The land is properly prepared and the trash incorporated in the soil after two or three passes over the ground. These disc harrows can be adjusted for cutting angle from the tractor seat and a second lever is used to adjust the depth of the levelling boards so that all the land preparation can be carried out with one implement.

OPERATING COSTS

It is too early to give absolutely accurate costings to compare land preparation by machine and by bullocks, but even the most prominent protagonists of animal power do not dispute the figures for capital outlay* given in *Table 1*.

The operating cost is based on 100 acres wet paddy cropped twice yearly; total area to be puddled 200 acres. Ten pairs of bullocks will be required

* Estimated for India in Indian rupees

Table 1. Capital outlay

Machinery	*Rs.*	*Animals*	*Rs.*
Tractor	7,700/-	10 *pair bullocks at Rs.* 1,000/- *per pair*	10,000/-
Implement	1,325/-		
Wheels	200/-	10 *bullock ploughs at Rs.* 22/- *each*	220/-
Accessories	175/-		
Total	9,400/-	*Total*	10,220/-

Table 2. Operating cost

Tractor	*Rs.*	*Bullocks*	*Rs.*
1 *Driver at Rs.* 2.8.0 *for* 62 *days*	155/-	*Labour*	
1 *Cleaner at Rs.* 1.0.0 *for* 62 *days*	62/-	600 *days at Rs.* 1.8.0. (*i.e.* 10 *drivers for* 60 *days*) ..	900/-
Fuel and oil			
500 *gal. powerine*	875/-	*Fuel and Food*	
31 *gal. petrol*	93/-	600 *days at Rs.* 2.0.0. *pr.* ..	1,200/-
15 *gal. oil*	112/8		
Incidentals	100/-		
Total	1,397/8	*Total*	2,100/-

to complete the puddling in the same time as one tractor. Average costs for this operation are given in *Table 2*, on the assumption that a tractor can complete one acre in $2\frac{1}{2}$ hours and a pair of bullocks require 3 days, and are believed to be applicable to many areas. No allowance is shown for depreciation since both animals and machine should be depreciated at the same rate.

In preparing these figures the economists have endeavoured to err on the expensive side for mechanical operation, and on the less expensive side for bullocks. Even so the advantage of mechanical cultivation is obvious from the financial angle. Above all the man on the tractor is many times more productive than the bullock driver.

The disc-harrow method of land preparation has been used in many areas of the rice-growing world, and while no controlled experimental work has been carried out, the farmers have invariably claimed that mechanical cultivation has given them an increase in yield.

Many pumps are available to assist in irrigation, so that the men in the past who have been employed on water lifting can leave the tractor and pump running by the well or canal while they carry out the essential operation of hand weeding, or spraying with knapsack sprayers. Most of the rice is grown in small fields, and while techniques are likely to improve in the future, there seems very little prospect in the present half century of aircraft spraying being applied to the extensive rice lands of Asia. New development schemes may, however, be laid out so that work at present being carried out by aircraft in America could be applied to these schemes.

Where there is reasonable water control the larger rice farmers will find a use for combines to do the harvesting. These have been produced with special tracks for buoyancy, and the normal rasp type of drum has been replaced by a peg drum. Between these and the hand operation with the

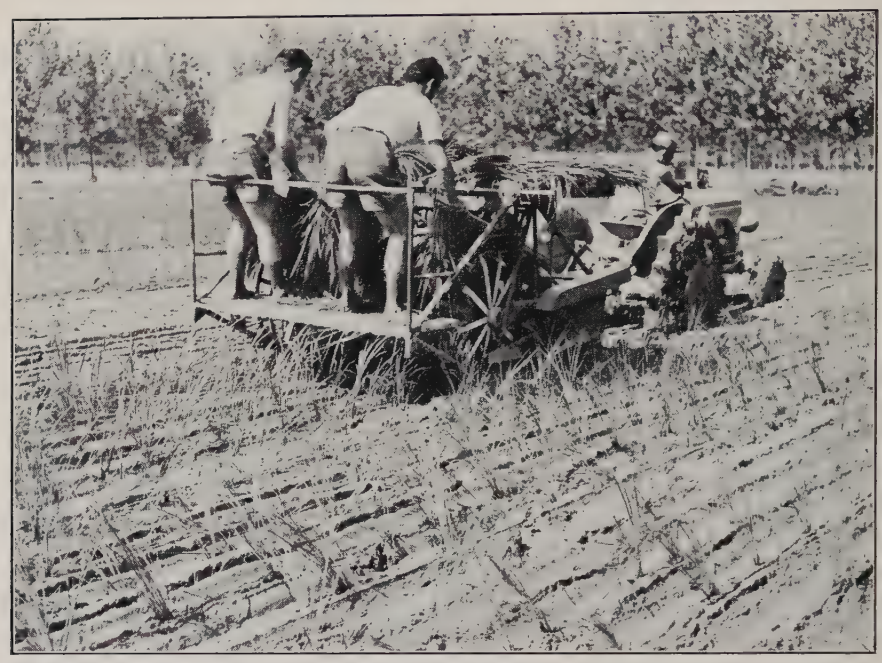

Figure 2. Transplanting: recent successful culmination of experiments in mechanical rice transplanting has enabled this transplanter to be produced in Italy

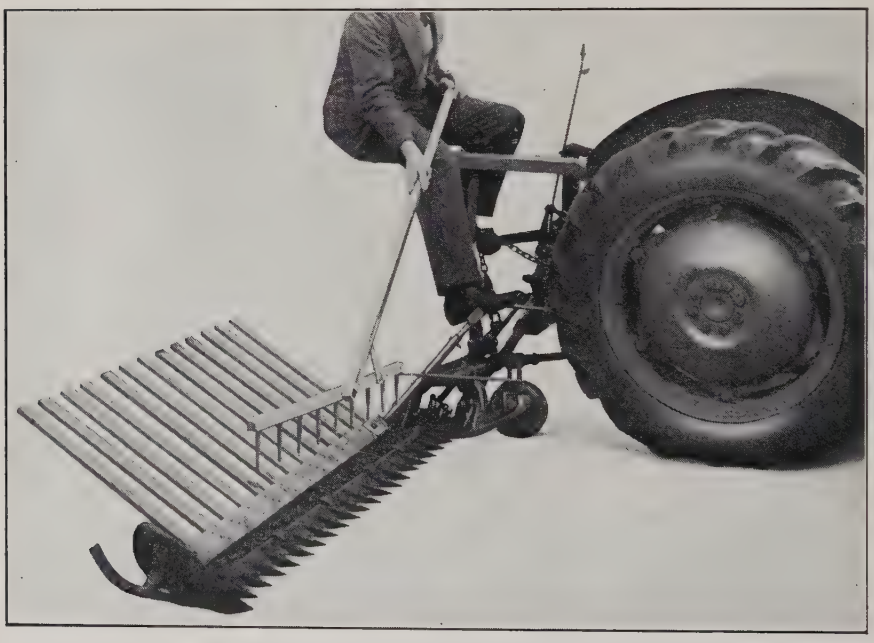

Figure 3. Harvesting: the agricultural mower with sheafing attachment is a means of quicker harvesting while keeping capital outlay low on small areas

sickle, or the small palm-held knife of Malaya, there appears to be a useful intermediate machine.

Many readers will have seen in use in Europe the ordinary agricultural mower to which is attached a sheafing board on the back of the cutter bar for cereal harvesting. A mower mounted on the hydraulic linkage of the tractor can be fitted with a sheafing board so that a second operator (additional to the tractor driver) with a specially designed rake in his hand, and using his right foot to tip the sheafing table, will be able to lay off sheaves with the grain heads all in the same direction for easy tying (see *Figure 3*). The tractor-mounted mower so fitted should be able to keep a

Figure 4. Thrashing and hulling: a cooperatively owned rice mill in Malaya which may be driven by the same tractor as used for the cultivations; transported from one community to another for hulling rice

gang of up to 20 men and women tying the sheaves and carrying them, if necessary, to the bunds.

The production of the sheafing table and additional seat are well within the bounds of any agricultural engineering department, and as this is a comparatively cheap addition to the agricultural mower, it is not at present being produced commercially. One firm of agricultural engineers has, however, undertaken to supply working drawings to its distributors or agricultural departments wishing to have details.

Between the combine and the flail lies a great gulf open to the designers and manufacturers of equipment suitable in manoeuvrability and cost to carry out the all-important operation of threshing. The requirements of such a machine are not easy to define, and several attempts have been made with fair success to meet some of the requirements. From Japan has come the successful foot-operated ' peg drum ', which simply threshes the paddy

off the straw. For this machine, the straw is held in the hand, and the rice is swept from the floor when threshing is completed.

The Department of Agriculture, Malaya, has recently been carrying out experiments with a semi-mounted thresher of medium capacity (see *Figure 4*) and has reported considerable success. The urgency of this problem of threshing varies from place to place, and it seems likely that the future will bring a number of different models, but all of them must aim at simplicity of design, and a price within the reach of the small grower.

There is a very wide range of rice hulling machinery and a large number of reputable firms already supply machines in large numbers. There is, however, room for development, which will not only reduce the labour element in this operation, but will be so efficient in hulling that only a very small percentage of the grains will be damaged.

The author recently examined a rice hulling mill which was mounted in a Ferguson trailer and driven by the power take-off shaft of the tractor. This outfit was owned cooperatively and it was able to drive from one village to another without unhitching. The tractor driver who was also the ' mill man ' became so competent in the setting of his machine that broken and damaged rice was hardly perceptible in the sample.

Incidentally, this portable mill carried in the same trailer its own office desk and scales so that complete records could be kept, and so that those using the mill would be charged the proper amount. This was a very lucrative business which was well supported by the housewives. The whole equipment was well protected against weather by a framework and waterproof sheeting, and the possibility of accidents was reduced to nil by proper screening of the power take-off drive and the several belts driving the mill.

Any mechanization scheme should endeavour to employ its machinery for the maximum possible hours each year, and in order to do this, those planning mechanization should keep in view the large amount of transport which can be carried out by a versatile tractor and trailer tailored to suit it. Figures applying to one industry may not be accurate if applied to another, but it is interesting to note that in Ceylon, a tractor with a three ton trailer capable of a top speed of about 13 m.p.h. has been costed in transporting the produce and requirements of tea estates, and shows a saving of about 50 per cent compared with a three ton lorry. In the bamboo industry in India, the same type of tractor and trailer was compared with bullocks for transport, and showed a similar saving.

Mechanization is only beginning but it is helping in many ways. The rice farmer in Tanjore, India, endeavouring to take two crops per year can, by mechanizing the puddling operation, grow his second crop also of a long term variety, since there is no delay between harvesting and planting the next crop. This long term variety will automatically give him a higher yield.

The Italian farmer, taking rice as his catch crop after wheat, prepares his land in April and May to transplant rice seedlings which will be irrigated with the water from the melting snows of the Alps. But in the past the limiting factor, on the acreage he could plant, was the availability of labour in the industrial north of the country for this unpleasant task. With the same labour and a transplanting machine, he will more than double the area

under rice, and he claims that because of the superiority of the machine, the transplanted seedlings do not show any ' transplant sickness ', thereby giving a high yield. The combine properly set reduces grain loss to nil, the thresher ensures that all the grain is taken from the straw, and the huller produces less ' seconds ' so that there is more rice for the ever increasing population.

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Green Coffee Production and Distribution

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E. Schluter & Co., Ltd, London

The coffee trade is fortunate insofar as much of it is conducted between old established firms of shippers, brokers, merchants and roasters whose members have been known one to the other over many years. This creates a family atmosphere but does not mean, however, that trade is not highly competitive. It is. It is a characteristic of the coffee trade that its members not only derive their living from handling the article but become enthusiasts over it, and often devote time to the close study of sides of the industry which do not directly concern them. The nature of coffee production and consumption is so diverse that no ' coffee man ' would claim to have a specialized knowledge of all coffees, though most specialize in some. Today the coffee industry is a thriving one, the chief import (by value) into the United States, the principal export from South America, the only source of income to millions of growers there and in Africa, and a new crop in countries which do not yet figure on any export list.

Several centuries ago coffee was discovered in Ethiopia growing wild, as it does today in many parts of that country. Coffee is of the genus *Coffea* of which there are many species but for practical commercial purposes only three—Arabica, Robusta and Liberica, are grown. Of these Arabica is the most delicate and gives the best liquor. It grows at high altitudes, usually above 3,000 ft. and up to 7,000 ft. above sea level, depending upon proximity to the equator. A temperature of 65° to 70°F is necessary since coffee is very sensitive to climatic changes. Frost could kill a tree and drought could reduce the yield considerably. Particularly favourable conditions of rain and temperature greatly increase the yield. A coffee tree does not produce commercially until it is five or six years old but the yield then continues unimpaired for about twenty years. It can be rejuvenated by extensive pruning to lengthen its commercial life up to about thirty years.

Robusta coffee reaches commercial bearing in a shorter time, is hardier than Arabica and flourishes at a lower altitude in wetter and more humid conditions. The quality varies considerably according to the care and attention bestowed in growing and the final preparation of the coffee beans. Robusta grows principally in east and west Africa and adjacent islands, in Trinidad, India and Indonesia. It accounts for about 5 to 7 million bags of total world production.

Comparatively, very few Liberica coffee trees exist. The bean is somewhat similar to Robusta, but larger and pointed at the ends; the taste is such that very soft water is required to support it. Liberica grows mainly in West Africa, Indonesia and Suriname and will be excluded from these considerations.

Brazil is the world's largest coffee producer, with Colombia second. Other coffees are grouped as Milds (Arabicas from Central America and

Mexico); Caribbean; Africans (Milds and Robustas); Mochas (Abyssinia and Arabia); Indonesians (Robustas) and Javas (Arabica). *Table 1* shows the comparative importance of the many origins, as well as pin-pointing coffee as growing between the Tropics of Cancer and Capricorn.

Table 1. World exportable production in bags of 60 kilos, × 1,000

(*a*) *Western hemisphere*

Location	*1949–50*	*1950–51*	*1951–52*	*1952–53*	*1953–54*	*1954–55*	*Main harvesting season*
Brazil	13,500	15,834	14,120	15,332	14,300	13,800	*May–September*
Colombia ..	5,900	4,900	5,099	5,705	6,200	6,350	*Large harvest—October–December Small harvest—April–June*
El Salvador ..	1,000	1,235	944	1,223	923	1,150	*November–March*
Guatemala ..	870	775	997	952	958	970	*November–March*
Mexico	575	850	814	1,233	1,100	1,500	*October–March*
Venezuela ..	560	350	378	590	350	550	*September–January*
Haiti	505	410	522	385	512	350	*September–March*
Dominican Republic	210	300	395	352	438	400	*October–March*
Costa Rica ..	325	262	316	518	357	525	*October–March*
Nicaragua ..	260	218	295	265	345	400	*November–February*
Ecuador ..	235	335	175	300	280	356	*June–August*
Honduras ..	65	113	134	187	190	210	*November–March*
Others	238	93	130	153	292	294	
Western total ..	24,243	25,675	24,319	27,195	26,245	26,855	

(*b*) *Eastern hemisphere*

Location	*1949–50*	*1950–51*	*1951–52*	*1952–53*	*1953–54*	*1954–55*	*Main harvesting season*
*Angola** ..	700	780	916	794	1,050	850	*June–November*
Kenya	100	161	271	191	185	203	*September–December*
*Uganda** ..	640	705	647	640	633	775	*September–December*
Tanganyika† ..	250	263	277	253	260	265	*September–December*
Belgian Congo† *and Ruanda-Urundi* ..	500	550	586	580	600	625	*May–December*
*Madagascar** ..	450	408	462	625	633	665	*June–October*
*French Cont. Africa**	850	1,250	1,480	1,288	1,698	1,810	*October–February*
Ethiopia ..	400	400	424	602	620	800	*September–January*
Arabia	90	90	100	90	90	90	*September–March*
*Indonesia** ..	150	251	348	307	790	600	*Three harvests per year*
Spanish Africa‡	110	120	98	100	105	95	*December–February*
Others	109	120	88	119	140	234	
Eastern total	4,349	5,098	5,697	5,589	6,804	7,012	
Grand total ..	28,592	30,773	30,016	32,784	33,049	33,867	

* Mainly Robusta.
† About one half Robusta
‡ 80 per cent Liberica

Brazil's share of world production has, however, fallen from 75 per cent in the early 1920's to 60 per cent in the late thirties and to less than 45 per cent in recent years.

Colombia has done much to increase plantings and to foster the breeding of higher yielding strains. The Mild Producers' Association of Latin America (FEDECAME), excluding Brazil and Colombia, does much to propagate the exchange of information and the results of experiment and research. The major advance in production has taken place in Africa from a total of about 2½ million bags in the immediate pre-war years to an estimated 6½ million bags in 1954–55 (see *Table 2*).

Table 2. African coffee exports in bags of 60 kilos

Location	*1934*	*1944*	*1954*
Kenya	150,257	103,115	182,821
Uganda	130,018	308,632	587,957
Tanganyika	250,052	263,515	328,912
French West Africa	45,466	407,583	1,580,371
French Equatorial Africa	11,051	51,700	83,623
Cameroons	13,426	84,583	193,698
Togoland	1,070	1,350	71,473
Madagascar	238,935	755,667	705,109
Belgian Congo & Ruanda Urundi	206,486	356,317	567,674
Angola	192,220	384,500	762,614
São Thome Principe	12,574	9,181	4,333
Cape Verde Islands	1,121	3,470	3,373
Ethiopia	374,750	222,299	620,325
Spanish Africa	8,500	88,434	85,496
Liberia	34,102	13,364	4,562
British West Africa	402	11,201	58,987
Total	1,670,430	3,064,911	5,841,328

Coffee is a plantation crop, although the plantation varies from one of thousands of acres in Brazil to the 50 or 100 trees owned by an African. There are many differences in producing methods, as between 'coffee agriculture' (Brazil) and 'coffee horticulture'—with small estates. Its success, economically, depends on a low cost of production with plentiful labour, plus an outlet for the finished product in areas of high income such as North America and Western Europe. Seeds are selected and planted in nurseries. The young plants are transplanted and at the same time or previously, in most countries except Brazil, shade trees are planted. The young plants are often protected by banana trees until the shade trees are sufficiently large. After two years the tree begins to bear and the fruit ripens about eight months after flowering. The maturing trees are carefully pruned and tended to keep down their height to picking reach by man. The soil is tilled and various fertilizers added, mulched, or not. Precautions are taken against pests or disease of which the borer beetle (*Stephanoderes*) is the chief, but probably a fungus (*Hemileia*) attacking the leaf is the most dangerous.

The fruit is in the form of a cherry the skin of which turns red when ripe and conceals a pulp which in turn normally contains two seeds each covered

by a flimsy 'silverskin' enclosed separately in a parchment envelope. These two seeds nestle flat sides together. Occasionally only one seed is contained within the pulp and this is called a pea-berry. The seed when the cherry is picked is firm in texture but contains about 60 per cent moisture. The seed is required to be exported as green coffee containing not more than 12 per cent moisture and devoid of its outer coverings. There are two methods employable to attain this: one is the 'dry' method, most commonly used in Brazil and usually for Robusta; the other, the 'wet' method, is used to produce Milds.

The 'dry' method is in effect arranging for the sun to dry the picked cherries which are spread out about 2 in. thick on a drying ground. This process depends entirely on climatic conditions and usually takes two to three weeks. After the cherry is dried the coffee if properly stored can be kept for long periods without deterioration. The husks are then removed by a hulling machine, the coffee being passed through a winnower and thereafter separated by size and weight into different grades which help to determine quality and price.

The 'wet' method results in a better controlled product and for that reason is usually used when there are abundant natural sources of water, or when the price obtainable for the cleaned product makes the extra expense of washing worth while. The cherries are dropped into large tanks of water, the immature ones float and the mature ones are drawn off below through conduits leading to depulping machines which separate the pulp from the beans. The beans are carried to fermenting tanks, which are drained of water; the beans are then left to ferment over a period from 16 to 48 hours, depending on temperature and altitude. This destroys the mucilage surrounding the parchment, and the violent washing which follows immediately removes all traces of this mucilage together with any pieces of pulp or dirt which might be present. The beans then flow through slotted channels with damming boards fitted at intervals. The coffee which is found in the first section after the water is drawn off is the heaviest and usually the best quality and so on until the end of the channels where the light beans or 'floats' are found. Thereafter the coffee in parchment is placed on drying grounds to reduce the moisture content. In its later drying stages, mechanical driers may be used. When the coffee in parchment has been reduced to 12 per cent moisture content the beans are ready for the removal of the parchment and silverskin to their green state. This is carried out by a huller of different construction from that used in the dry method. Some coffees—depending on the hardness of their bean—are polished to enhance appeal to the consumer's eye and thereafter graded for weight and size.

Quality is dependent on the preparation described above, as well as on strain of breeding, care in growing and not least on soil, climate, rainfall, altitude and absence of pests and diseases. Quality can only be spoilt thereafter by lack of proper respect for the commodity in handling, storage or transport. Coffee must not be stored in humid conditions or unprotected from the bare earth. It must be properly stowed below deck on board ship so that it does not sweat nor is contaminated in any way by proximity to other cargo, by seepage, by sea-water or by fresh-water. It must not be

stored too long once it has reached its green state. Contamination, age or any fault in preparation and even penetrating insecticides can be detected by the expert coffee taster.

Some of the finest coffees in the world grow in India, Kenya, Costa Rica, Guatemala, Hawaii, Java (all Milds) and Brazil. The finest coffees of India, Hawaii, Java and Brazil contain well balanced properties of acidity, body and flavour, whilst those from East Africa, Costa Rica and Guatemala are renowed for their high acidity and aroma.

Coffees from British territories compare favourably with their rivals; the highest prices are those paid for Kenyas. In many British territories research is continuous and improvement can be detected from year to year. The Kilimanjaro Native Co-operative Union (K.N.C.U.) centred around Moshi and Mount Kilimanjaro is a cooperative formed by coffee planters of the Chagga tribe which has proved the pilot for many native cooperatives. Coffee is one of the two legs on which Uganda stands economically (the other is cotton), and during the last two years organization and grading have been completely overhauled under a special coffee ordinance.

Jamaica has a Coffee Industry Board which was formed by the local government to control and improve production and output. In 1954 an entirely new central grading works was opened and has proved itself in the standardization of types hitherto subject to variations. Trinidad produces Robusta of good quality but no general standards are laid down. British West Africa is as yet an undeveloped area with regard to coffee but the potential for Robusta is great. Coffee has long been produced in New Guinea and Malaya ; Siam, the Central African Federation, the Sudan and other territories are starting production now.

In *Table 3* a summary of the main countries of consumption is given from which it is apparent that the United States exercises the same influence from the consumers' view-point as Brazil does from the producers' point of view. The people living in what is now known as Eastern Germany were avid coffee drinkers, as were the populations of Poland, Czechoslovakia, Hungary and Rumania. These consumers have been temporarily lost but are a potential source of demand.

It is evident that the coffee produced in British territories can be a large dollar earner and indeed, depending upon demand, frequently is. In general the United States does not pay fancy prices for fancy coffees but would rather have a good average coffee available at an average price. In certain countries in Europe, however, the opposite is the case and particularly in Germany, Switzerland, Belgium and Sweden the quality demand is of the highest and prices are paid accordingly. In many countries the size of the bean has greater influence than its inherent quality and premiums can be obtained for large bean coffee. There is in fact one breed of coffee called Maragogype (whose name derives from the district in Brazil where it was found growing) which commands a very high premium. The yield is so low, however, that production is declining. Italy and Belgium roast their coffee to a higher degree than elsewhere and consequently look for different merits in their green coffee purchases. Turkey on the other hand pulverizes the bean after roasting and requires an entirely different kind of coffee. Turkey through economic dictates now buys only Rio coffee, which is one

Table 3. World imports of green coffee in bags of 60 kilos, × 1,000

(*a*) *Western hemisphere*

Location	*1951*	*1952*	*1953*	*1954*
United States	20,357	20,274	21,065	17,064
Canada	669	752	813	721
Argentina	476	518	571	562
Chile	68	67	99	91
Uruguay	42	41	61	55
Others	147	41	51	42
Total	21,759	21,693	22,660	18,535

(*b*) *Europe*

Location	*1951*	*1952*	*1953*	*1954*
France	2,522	2,681	2,842	2,811
Italy	889	1,016	1,112	1,158
West Germany	677	949	1,311	1,703
Belgium and Luxembourg ..	912	876	873	712
Sweden	699	793	854	802
Great Britain	721	720	507	559
Norway	257	367	311	289
Finland	246	363	384	466
Denmark	272	343	426	405
Netherlands	283	328	471	461
Switzerland	331	304	319	319
Portugal	140	175	151	145
Turkey	114	115	108	109
Spain	102	115	102	123
Greece	101	85	101	83
Austria	85	76	70	80
Others	283	199	236	166
Total	8,634	9,505	10,178	10,391

(*c*) *Africa*

Location	*1951*	*1952*	*1953*	*1954*
Algeria	353	319	333	348
South Africa	198	198	196	174
Egypt and Sudan	185	195	183	149
French Morocco	60	60	70	69
Others	74	35	37	83
Total	870	807	819	823

(*d*) *Asia and Oceania*

Location	*1951*	*1952*	*1953*	*1954*
Philippine Republic ..	65	25	16	14
Australia	58	28	71	62
Iraq	38	74	31	11
Syria and Lebanon	43	42	50	34
Japan	22	36	56	53
Others	169	156	218	38
Total	395	361	442	212
Grand total	31,658	32,366	34,099	29,961

of the poorer qualities of Brazil, and cannot be persuaded to take a finer quality. One of the arts of distribution lies in an intimate knowledge of each buyer's requirements—nationally and individually.

Apart from the more traditional method of roasting and grinding coffee, soluble coffee has been developed. This is an 'instant' coffee which is generally derived from pure coffee without additives. Before the war most brands contained carbohydrates and dextrose. For the manufacture of solubles the coffee must first be roasted and ground as usual. A beverage is then brewed which is concentrated and dehydrated by vacuum drum or spray drying. Tiny coffee crystals remain which are known as soluble coffee. Ease of preparation makes soluble coffee attractive to an increasing number of consumers and it is estimated that by 1960 half the coffee consumed in the United States will be soluble coffee.

The roaster very rarely uses single qualities or origins of coffee. Coffees of different origins contain different properties and merits and the roaster blends these and obtains a result which he then contrives to match and maintain to keep his consumer satisfied. The purchasing of the constituents of the blends is one of the roaster's problems to which he turns to the distributor for solution.

In the chain of distribution of green coffee there are many points (in time and place) of sale by contract and many points (by physical delivery) for quality checking. Before export is permitted coffee is usually classified and graded to conform with the specified standards of the producing country and the parcel examined is accorded a quality certificate. This, however, does not normally absolve the shipper from quality responsibility since he is held responsible for shipping coffee in sound condition and the only quality variation allowed on arrival at port of destination is that incurred by the duration of the voyage during which, of course, all damage is covered by insurance. On arrival at port of destination the coffee is unloaded and inspected on landing for signs of damage, loss or contamination, by experienced wharfingers whose business is handling coffee. Samples are then drawn for examination by the owner for submission to the seller in case of need. If the coffee is to be resold then these out-turn samples are used as the basis for re-sale. In most consuming countries there is an import duty on coffee and so coffee is generally stored in bonded warehouses until required by the eventual roaster for use in his roasting plant.

In some countries the planter is paid for the weight of cherry he delivers, whilst in other places the marketing commences with the sale of the dried cherry or of the coffee in parchment. In many instances the planter produces his own green coffee and his marketing problems only commence then.

Once coffee has reached its green state it is passed on to an Exporter/Shipper who generally buys it in the interior and sells it on an F.O.B. (free on board steamer) basis. Shippers sell to merchants, importers, distributors, and sometimes to roasters directly or through selling agents. Merchants, importers and distributors employ selling agents or brokers to sell to roasters and occasionally to other merchants, importers or distributors.

Coffee can be traded at port of origin in warehouse, F.O.B.; C. and F. (cost plus ocean freight to port of destination); C.I.F. (cost plus insurance

plus ocean freight); ex-dock port of destination; *etc*, according to need and opportunity. It can be traded for immediate delivery or for forward delivery and sometimes coffee is traded and quoted up to twelve months ahead.

There are actual coffee markets and there are terminal coffee markets. Actual markets are those where coffee is physically delivered against contracts. Terminal markets are those where the seller has the option to deliver actual coffee against his sales contract or to buy back his sales contract by making, prior to its delivery time, a purchase contract equal in quantity to his sales contract and paying or receiving the difference in price. Such terminal markets are normally operated by a clearing house in conjunction with a coffee trade organization in the major coffee distributing centres where the terminal market is formed. Terminal markets are used for ' hedging '. The reasons for ' hedging ' can best be explained by the wish or need of the planter sometimes to sell his crop before it is picked, for the distributor or roaster to protect his stock by selling an equal quantity of other coffee, for the roaster to do likewise or for the roaster to preserve the wholesale or retail price of his roasted coffee by buying forward. All this may be difficult or impossible with actual coffee but may be more easy on a terminal market where on an average (depending on current conditions) actual coffee is delivered against only 3 per cent of the contracts entered into.

Coffee is often offered for public sale by auction in producing or consuming countries. Some producers prefer this method of primary sale of green coffee, whilst some distributing centres (in pre-war years London was the main one) use an auction to advertise their *entrepôt* stocks.

There is no universal standard for the grading of green coffee, but the most commonly used method is that of counting the defects, the yardstick for which is one black bean.

Grading table of Brazil types—Types are classified by defects in tins of 300 grams. Type 1 theoretically would contain no defects but the possibility of this type being produced is remote. Type 2 contains a maximum of four defects, and types 3, 4, 5, 6, 7, and 8 contain maxima of 12, 26, 46, 86, 160 and 360 defects respectively. The following are equivalent to one defect: one black bean, two sour beans, two beans in parchment, three shells, five quakers, five unripes, one pod, one longhusk, two or three small husks, and one small stone or stick. A medium stone is equivalent to two defects and a large stone is equivalent to five defects.

Standard for ' usual good quality ' Colombian Excelso—Usual good quality Colombian Excelso coffee may not contain more than 13 full faults in a volume of 36 cubic inches (the contents of a cylinder 4 in. in diameter and $2\frac{7}{8}$ in. high or a rectangular container of approximately $7\frac{1}{2}$ in. length by $4\frac{1}{2}$ in. width by $1\frac{1}{8}$ in. height). Usual good quality Colombian Excelso coffee shall be understood to be of the crop which is current at the time of shipment.

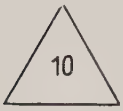
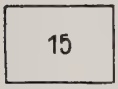
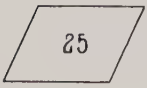
The following are equivalent to one fault: one full black bean, one full sour, one pod or cherry, five shells, five broken or cut beans, two to five partly black or partly sour beans, five floaters, three small sticks or stones, one medium stick or stone, two to three hulls or husks, and two to three beans in parchment. A large stick or stone is equivalent to two or three faults.

Costa Rica coffee—This is sold on the basis of estate marks which are

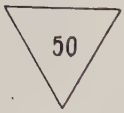
described as hard bean; strictly hard bean; low grown Atlantic; high grown Atlantic; according to the situation of the estate on the central plateau where the coffee is grown. These descriptions stand only for the type of bean and cupping characteristics as a result of regional growth specialities and have no bearing on processing practices.

Thus some good hard bean coffees may well be found to be more nicely presented and freer from defects than some strictly hard bean coffees. The only reliable guides are actual samples, or the reputation of an estate built up over years, or the detailed description of a reliable shipper.

UGANDA ROBUSTA COFFEE

Grade and mark	*Description*
Uganda Robusta Grade 5	To consist of clean and dry beans of good appearance for the quality, free from all trace of mustiness, of husk and of extraneous matter, and to contain not more than 5 per cent by strict count of defective beans, which shall be inclusive of not more than one per cent by strict count of black beans or unhulled coffee.
Uganda Robusta Grade 10 	To consist of clean and dry beans of reasonably good appearance for the quality, free from all trace of mustiness, and to contain not more than 10 per cent by strict count of defective beans, which shall be inclusive of: (a) not more than 2 per cent by strict count of black beans, and (b) not more than one per cent by strict count of unhulled coffee—and in addition, there shall be not more than one tenth of one per cent by weight of extraneous matter.
Uganda Robusta Grade 15 	To consist of clean and dry beans of reasonable appearance for the quality, free from all trace of mustiness, and to contain not more than 15 per cent by strict count of defective beans, which shall be inclusive of: (a) not more than 5 per cent by strict count of black beans and (b) not more than one per cent by strict count of unhulled coffee—and, in addition, there shall be not more than one fifth of one per cent by weight of extraneous matter.
Uganda Robusta Grade 25 	To consist of clean and dry beans, free from all trace of mustiness, and to contain not more than 25 per cent by count of defective beans, which shall be inclusive of not more than one per cent by count of unhulled coffee, and, in addition, there shall be not more than one half of one per cent by weight of extraneous matter, nor more than 3 per cent by weight of husk.

Uganda Robusta Grade 50



To consist of clean and dry beans, free from all trace of mustiness, and to contain not more than 50 per cent by count of defective beans, which shall be inclusive of not more than 2 per cent by count of unhulled coffee, and, in addition, there shall be not more than one half of one per cent by weight of extraneous matter, nor more than 5 per cent by weight of husk.

Definitions

'Black beans'—completely black beans, both externally and internally.

'Defective beans'—partly black beans, abnormally pale and discoloured beans, insect-damaged beans, withered and shrivelled beans and badly broken beans. A badly broken bean means less than half a bean.

'Dry coffee'—coffee of a moisture content of not more than 12·5 per cent by weight, or coffee that loses no further weight when left for twenty-hour hours in an oven temperature maintained at 100°C.

The term 'extraneous matter' applied to Robusta coffee does not include Arabica coffee.

Side by side with grading goes, in most instances, description of colour, roast and cup. According to origin, colour varies from blue through grey to green, yellowish and brownish, with blue/grey being the most desirable. Roast is described from fine to poor (with the taster's note of it being bright, ordinary, dull, *etc*). The cup is also described and can be said to be mild; mellow; acid; of fine acidity; sweet; soft; strictly soft; whilst faults lie within the range fruity; sour; green; grassy; harsh; common; hard; woody; earthy; musty; unclean; foul; tainted. It should be noted that the hardness of cup has nothing at all to do with hardness of bean. The former is a fault and the latter a merit.

Much has been said in law about the construction and interpretation of contracts, but the coffee trade prefers to engage in arbitration rather than law if amicable settlement of any dispute is found impossible. Arbitrators are the 'Elder Statesmen' of the coffee world whose experience extends over decades. Each main trading centre has its form of contract, coffee trade association, arbitration rules and arbitrators, and on a great number of points agreement is found in most of these centres.

Coffee is an expensive commodity with prices ranging today from Robusta at £240 per ton F.O.B. to Arabica at £650 per ton F.O.B. Bank help is often enlisted to finance the movement of coffee to effect its sale. This means transferring the title to the goods to the bank, who in turn require the title to be given by the issuing of warehouse warrants or bills of lading in every case by the most reputable of warehousemen or steamship agents. Bankers in turn must know the value of the commodity they are financing. They may in extreme cases employ coffee brokers to determine the value of the coffee or, where the bank finances a planter's crop, to sell the coffee.

At present the coffee trade is facing difficult problems caused by an over-production in the cycle which varies between over-production and under-production. But the situation today is unique, with Brazil just recovering from a severe frost in July, 1953, and threatening a surplus of eight

million bags by the end of June, 1956, with at the same time a frost in August, 1955, threatening to cut production in 1956–57 so that on balance an average equal to potential consumption might be struck. Milds, after having record crops in 1954–55, were hit by rain damage in late 1955 just as the majority were maturing. This means a possible shortage of Milds during the middle of 1956. In August, 1954, President Vargas committed suicide after the failure of an attempt by Brazil to enforce a high minimum price for coffee. Confidence in the coffee market was temporarily shattered. Producers combined to support prices. Roasters and distributors holding large stocks used them up instead of making new purchases. Support prices crumbled; instability reigned. Coffee became a political issue in the United States and headline news.

Prices during the past six months have recovered considerably, but the market is as volatile as the oils in the coffee bean, and coffee-men do not easily forget that the factor of price increase for coffee since 1939 is higher than that of any other commodity. The natural corollary is increased production. The areas for this in the Eastern Hemisphere are largely untouched. The duration of the high price cycle may thus be limited, though coffee planting will remain economic in the foreseeable future.

(*Received February 1956*)

Citrus and Subtropical Fruit Research in South Africa

R. H. Marloth

Director, Citrus and Subtropical Horticultural Research

Compared with other fruit-growing countries of the world, the citrus and subtropical fruit industries of the Union of South Africa are of comparatively recent development. Today they play a relatively important part in the agricultural economy of the country, citrus alone contributing over £10 million annually, from export and sales within the country, to the national income.

Although the first citrus trees were introduced into South Africa in 1654, it is only in the last fifty years that commercial plantings were made, the later rapid development of the industry being based on the export of the fruit to the United Kingdom, there having been a boom in tree planting after World War I. Citrus was planted in widely-dispersed areas having a wide variety of climatic conditions and on all soil types. Today the main citrus-growing areas are in the North Transvaal, Eastern Transvaal and West Transvaal, the Eastern and Western Cape Province and in Natal. The main variety grown is the Valencia orange, followed by the Washington navel orange, while other oranges, grapefruit, lemons and naartjes (tangerines/mandarins) together account for only 15 per cent of the total production equivalent to over 20 million pockets of 30 lb. each. The citrus industry today is highly organized, and the production and marketing problems of the 2,500 growers are ably administered by the South African Co-Operative Citrus Exchange formed in 1926 and the Citrus Board established in 1939.

The coastal climate of the Eastern Cape Province and of Natal and of the Transvaal Lowveld extending up to the Limpopo River is very suitable for the cultivation of subtropical fruits. Till some thirty years ago commercial plantings were restricted in size and number, the many types of subtropical fruit being grown mostly in home orchards. The development of the subtropical fruit industry, unlike that of citrus, has been dependent on the tremendously increased demand for these fruits on the South African home market, with the exception of the demand for pineapples for export from canning factories. In 1954 over 5 million packages of subtropical fruit were sold on the eight principal markets in the Union alone. Considering the number of young trees of mangoes, litchis, guavas, avocados and pecans coming into bearing and now totalling over two million, and the production from 16,000 acres under bananas and from 35,000 acres of pineapples, to which additional planting is continually being undertaken, plus the production from the thousands of acres under granadillas and papayas, it will not be many years before the total volume of fruit available for disposal will be doubled, if not trebled.

While the original development of plantings of subtropical fruit was in Natal, today the Eastern Transvaal Lowveld dominates the commercial production of these fruits, with the exception of pineapples whose commercial development was in the Eastern Cape Province which still leads by far in this field. In the Lowveld the growing of citrus and subtropical fruit under irrigation is closely related, and the time is not far distant when the large-scale new plantings both made and planned of citrus and other subtropical fruit will result in this area making a dominant contribution to the supplies of these fruits, not only for the 12½ million population of the Union, but also to overseas countries.

Figure 1. Main administrative and laboratory building of the Nelspruit Research Station

THE CITRUS AND SUBTROPICAL HORTICULTURAL RESEARCH STATION

The Warmbaths Citrus Experiment Station, started by the Transvaal Department of Agriculture in 1904 and closed down in 1918 following the citrus canker outbreak, was indicative of the need for research in the then still very young citrus industry. Next, a specialized station at Buffelspoort in the western Transvaal for research on citrus canker and other citrus diseases was started in 1922, but the now rapidly-growing citrus industry still lacked facilities and staff for investigating the many major problems which, with its development, were becoming apparent. On the invitation of the Union Department of Agriculture, the world-renowned citriculturist, H. J. Webber, for many years Director of the Citrus Experiment Station at Riverside, California, visited the country in 1925 to report on citrus growing in the Union. One of the terms of reference was to review the whole position of present and potential citricultural research and to

recommend a location for the establishment of an experiment station for citrus research.

Since it was decided that the main station to be established was to serve the Union, with possible sub-stations, this recommendation was not an easy one to make on account of the varying climatic conditions under which citrus was being developed commercially and because of the distances of up to 1,500 miles by rail between such citrus-growing areas. Of the three final possible areas selected, Nelspruit in the eastern Transvaal, with a climate of summer rainfall and mild winter, was decided upon by the Department of Agriculture.

The research station is some 380 acres in extent, situated 2½ miles from the rapidly-developing town of Nelspruit on the main railway line from Pretoria to Lourenço Marques. A sub-station at Alkmaar, 12 miles distant, makes available a much heavier soil type than that which occurs at Nelspruit for large experimental orchards in which comparative rootstock and cultural practice problems are investigated under commercial growing conditions. Recently, development has started on the Citrus Research Station at Addo in the eastern Cape to serve an area in which soil and climatic conditions are entirely different to those obtaining in the eastern Transvaal.

From its inception in 1927, the Subtropical Horticultural Research Station, now renamed Citrus and Subtropical Horticultural Research Station, was a sub-section of the Horticultural Section of the former Division of Plant Industry of the Department of Agriculture. With the creation of a separate Division of Horticulture in 1938, the Nelspruit Station became a section of that division. In 1952 the new Directorate of Technical Services came into operation, and the Nelspruit station is now a specialized institution directly responsible to the Secretariat of Agriculture, and serves the citrus and subtropical fruit industries of the Union.

The present staff consists of 26 professional and technical officers, with eight administrative and five farm personnel, and a native labour force of 80. Provision is made for a considerable augmentation of the staff, but with the great shortage of suitably-trained personnel throughout South Africa, considerable difficulty is being experienced in filling many of the vacant research posts.

RESEARCH PROBLEMS AND ACTIVITIES

The two main phases of research, which Webber considered in 1925 as being the most important and urgent to undertake for the citrus industry, were those of fertilization and of rootstocks, and on these work was concentrated with the arrival of California-trained research workers in 1930. The twenty-five acre long-term Citrus Fertilizer Project orchard of Valencia orange sister trees at Nelspruit is providing much fundamental knowledge on the mineral nutrition of the citrus tree, while supplementary fertilizer trials on other soils and in other areas, sand culture experiments, and nutritional spray trials assist in providing the answer to specific fertilizer problems. The newly equipped spectrographic laboratory will enable workers to investigate fully the rôles of the all important minor elements as well as those of the hitherto-considered major elements. The citrus rootstock investigations are very comprehensive some 4,000 data trees having

been planted on various soil types and in different areas, over 150 stock selections having been used for some 25 varieties. This rootstock work has become of great importance in view of the heavy toll which various virus complexes are taking of established orchards in other citrus-growing areas of the world as well as in South Africa.

Figure 2. Basin irrigation system in citrus fertilizer orchard: 4 in. of water being applied over 100 per cent of the soil surface under Valencia orange trees 15 years old; yielding more than 600 lb. of fruit per tree per annum

The water requirement of the citrus tree under summer-rainfall conditions, including the cross-transfer of solutes, has been the subject of special study at Nelspruit, while at the Alkmaar Sub-station a long-term citrus irrigation project is being conducted. Other cultural projects at Alkmaar include a cultural project in which such methods of cultivation and non-cultivation as permanent leguminous and non-leguminous ' sods ' are being compared with clean cultivation and summer cover crops alone. The influence of the time of harvesting and of an out-of-season crop on the normal crop of Valencia oranges is being determined. An espacement project has recently been planted in which the relative yield and cost per acre of twice as many trees per acre as are normally planted are being compared. Technique in nursery practice and growth studies of the roots, tops and fruit have done and are doing much to assist in the understanding of the behaviour of the citrus tree from the day it is planted, and in the interpretation of results obtained from differential treatments in the many investigational projects in hand.

The station is justly proud of its various fruit variety orchards, in which most of the world's leading commercial varieties of different subtropical fruits are being compared, many being on different rootstocks. These orchards serve not only as adaptability trials, but also provide budwood for distribution to growers, and serve as a living herbarium for the study of

these fruits. The citrus variety orchard has some 400 species, varieties, and selections established in it, while the numbers for the other variety orchards are: 80 avocados, 70 mangoes, 40 pecans, 25 litchis, and 150 miscellaneous, included in the latter being 25 subtropical peaches, 10 loquats, 15 guavas, and eight dates. The vegetative propagation of these subtropical fruits forms a separate intensive project, while the relative commercial performance of the most promising early, mid-season, and late citrus varieties is being determined in special orchards at Alkmaar.

The Lowveld has been termed the winter vegetable garden of the Union, and a considerable proportion of the activities of the Nelspruit station is devoted to research and advisory work in the field of vegetable production. This form of culture, also being entirely under irrigation, is to a great extent undertaken by those who are also growers of citrus and subtropical fruits. The major vegetable crop is the tomato, and the Station's contribution in producing mother seed of varieties, old as well as new, resistant to the all-destroying *Fusarium* wilt has enabled this culture to prosper. Other commercially important vegetables are cabbages, peas, sweet potatoes, cucurbits (particularly squashes), brinjals, onions, and now possibly, as the result of recent varietal trial work, cauliflowers. With the major types comprehensive varietal, time-of-planting, espacement, and fertilizer experiments constitute a sphere of the research programme being carried on.

The plant pathological and the entomological sections have to divide their time between research work on specific problems of diseases and pests, respectively, which afflict the crops grown in the Lowveld, and on advisory work in direct contact with the farmers in assisting in their control of those diseases and pests with which the grower has to fight continually. Being a summer-rainfall area, the incidence of these maladies often differs in behaviour from those in other areas and other parts of the world, and the research workers must often work out new methods, even with time-proven fungicides and insecticides. A grower's financial success or failure often depends on the results of the investigational work of these sections.

Until 1949 all departmental investigational work on the handling and storage of citrus and subtropical fruit for the Union was effected through the former Low Temperature Research Station in Cape Town and the Chief Government Fruit Inspector. The new low temperature laboratories at the Nelspruit station with their eight chambers, with independent units which will allow controlled temperatures ranging from 28°F to 75°F with three degrees of humidity and variable air or gas supplies, plus the deep freeze units, are considered most up-to-date. These allow fundamental and detailed research on low temperature storage problems of citrus, subtropical fruit varieties, and winter vegetables with fresh material harvested in its zone of production.

Although the staff of the station is primarily engaged in research work, in view of horticulture being a specialized subject, the knowledge of the technical officers is always at the disposal of those growers seeking general information and enlightment on their problems. A full-time advisory horticulturist with the assistance of his colleagues deals with literally thousands of enquiries received annually, not only from all parts of the Union but also from outside. Growers of the Lowveld take advantage of the

proximity of the station to their farms, and the number of visitors wishing to see the research work in progress proves embarrassing at times to the relatively small staff of professional officers engaged with a heavy load of investigational work on only some of the problems they would like to tackle. Nevertheless such interested growers are always welcome, for the written word through letters or publications cannot always impart so satisfactorily the information which could be gathered through seeing and hearing. This advisory work is an important function of the station, a function which it is hoped to develop considerably.

In recent years the Nelspruit station has been pleased to welcome a number of research workers from overseas. Office and laboratory facilities are gladly placed at the disposal of such visitors, it being considered that such interchange of research workers with new ideas and different outlooks is of great value in the furtherance of the solution of the many problems with which the citrus and subtropical fruit industries of South Africa are continually confronted.

RESEARCH AT OTHER INSTITUTIONS

Although this article is intended to deal primarily with the Citrus Research Station at Nelspruit, to complete the picture of citricultural research in South Africa brief mention must be made of other institutions and bodies which conduct research in this field.

Various national divisions of the Department of Agriculture, such as horticulture (which includes fruit inspection), entomology, and plant pathology in the past undertook a considerable amount of research on citrus problems affecting their own fields. Also research workers at the Agricultural Research Institute of the University of Pretoria and at the Western Province Fruit Research Station have made valuable contributions towards solving specific problems in various areas, especially the Eastern Cape and the Western Province. The S.A. Co-Operative Citrus Exchange through its Technical Section and with its Field Officers has undertaken and is still engaged on a large number of research projects and trials in the field throughout the Union, often in cooperation with different Government institutions and divisions. Important contributions to research, particularly on a commercial basis and in the applied form, come from technical officers with fully equipped laboratories maintained by a few large citrus estates. Recently the University of Rhodes at Grahamstown, through the Fitzpatrick Memorial Trust Fund, has started research on certain problems affecting citrus production in the Eastern Cape.

With a view to coordination of effort and the exchange of opinions so as to obtain a better perspective of the citrus growers' difficulties, the industry a number of years ago brought about the formation of a Citrus Research Committee on which workers from all the aforegoing were represented. This committee is being replaced in its functions by a Department of Agriculture Citrus Research Committee, whose function will be primarily to coordinate all citrus research undertaken with government funds, and to advise the Minister of Agriculture with regard to problems facing the citrus industry of the Union, and to propose definite means of dealing with them.

(*Received January 1956*)

An Account of the Date Palm by Francesco Redi, A.D. 1666

Translated by

V. H. W. Dowson

F.A.O Mission, Tripoli, Libya

The palm is a very common and very useful tree in Asia and Africa, but in Europe, particularly in our Italy, it is seen but rarely, and, if it is seen, either it gives no fruit or the fruit does not mature. Of this, there is not only daily experience, but there is also the evidence of Pliny in the 13th book of his *Natural History*; and, before Pliny, Varro mentions it in the 2nd book of his *Rerum Rusticarum* (*sic. De Re Rustica* ?)*†.

The palm likes the plain but it is also at home on the mountains provided there be springs there, for there is nothing the palm dreads more than drought, which damages it and kills it, so much so that, although it likes to be well manured and supplied with dung, nevertheless, this is harmful to it in dry years and in places where there is no possibility of watering it abundantly, but if there is water which is applied at the right time, and if the soil suits it, the palm will grow and bear so heavily that sometimes one palm will give two camel loads of dates.

Whereas, according to those who write of the qualities or nature of plants, all plants have a male and a female, yet in no plant is this more evident than in the palm, because they relate that the female will not conceive or bear fruit without the male, and that around the male many females stretch forth their fronds, and it would seem that they entice and coax it, while the sight of him, rough and robust, with his breath, and with his powder makes them gravid. If the male dry up or be cut off, the females growing around it may be said to become widows, for they become sterile**.

A. Tazio in the first book of the *Loves of Leucippus and Clitofont* tenderly describes these loves of the palm, and the following also have mentioned them

(Translator's Note:

I have translated the article by Redi because it appeared to me of interest in that it contains, so far as I am aware, the first rational account in a European language of the pollination of the date palm, the preparation of date syrup, and the use of the date-palm heart and date-palm sap (*lagbi*). He is the first European writer to mention six well known North African varieties of dates which, so far as he goes, he describes correctly. He, however, confuses the date palm with the Theban palm (*Hyphaene thebaica* Mart.) and with the oil palm (*Elaeis guineensis* Jacq.). His article *Concerning the Nature of Palms*[1] (*Notizie intorno alla natura delle palme*) was written 'for Signor N.N.' and is dated 1 May 1666. Dr Redi states that his information was obtained from Khawaaja Abul Gheith bin Faraj es-Sa'id, who was educated in the celebrated schools of Fez and, by virtue of his qualifications, sometime attached to the court of Hajji Mustafa Laas, King of Tunis. M. d'Herbelot is said to have consulted him about oriental languages.—V.H.W.D.)

*The Capuchin Father, G. A. Cavazzi of Montecuccolo in the *History of the Three Kingdoms, Congo, Matamba, and Angola* (*Istoria de' tre Regni Congo, Matamba, e Angola*), speaks at length of the palms. Also there are many excellent notes on these plants by F. Gemelli, in his *Tour of the World* (*Giro del Mondo*), published in Venice, Vol. 5 (1719), p. 102 *et seq.*, and in a short work on the palms printed in Florence in 1693.—F.R.

†(The commentator may be confusing the date palm, a native of the sub-tropics, with tropical palms.—V.H.W.D.)

**Pliny was of this opinion, as may be seen from the 13th book of his *Natural History*, already mentioned.—F.R.

with equal grace: T. SIMOCATE in *The Epistles*, M. GLICA in *The Annals*, A. MARCELLINUS, and CLAUDIAN who, in *The Marriage of Honorius* (lines 65 & 66) wrote:

Vivunt in Venerem frondes, omnisque vicissim Felix arbor amat, mutant ad mutua Palmae Foedeta . . .

All those writers, however, wrap up the truth in a thousand poetic conceits, so much so that, as Abul Gheith tells me, it is not true that the male should be planted near the female, nor that it should be seen by the female, nor that the female should smell its odour, because there are gardens and palm groves where there are no males, yet the females there are fertile, and furthermore, if, in places where there are males, these are removed, the females will not for this reason cease their yearly bearing. It is, nevertheless, true that the male contributes something towards the fecundation of the female and I shall here write to Your Lordship what I have been able to understand of the matter, and this is that the palm, from the age of three, four, or five years to the age of one hundred, produces, at the beginning of each spring, at the place where many of the lowest fronds join the trunk, an involucre, called by DIOSCORIDES φοῖνιξ ἐλατίς*, which grows to about half the size of an arm, and which then in the month of April, when it is the time for flowering, of its own accord, splits, and opens, and is seen to be full of very many white stalklets bearing a large number of milk-white flowers resembling those of jasmine, with a little yellow in the middle. These spathes and these flowers are borne by both males and females; but the male flowers, which have a pleasant smell, and from which falls a certain white powder, like chestnut flour, sweet and delicate to the taste, however vigorously they grow, never develop into dates, although THEOPHRASTUS was of a contrary opinion**.

On the other hand, the female flowers, which do not smell sweet, and which do not produce the dust, produce dates in large quantities, provided certain things are done. When the flowers begin to burst out of the involucre, that is to say the spathe, this spathe is cut away all round, and the flower stalks are left exposed. Between them are inserted two or three branchlets of flowers cut from the male. The whole is now tied up and left so until the rod-like branchlets of the male have withered, when the tie is undone. It is thus that the female is fecundated. Without such fecundation the dates do not reach perfection or full maturity. I myself do not know whether this practice is a superstition, or just perhaps a useless habit. However, the custom is very ancient; and A. Tazio was indulging in fables when he said that, if the male palm is planted a long way away from the female, it withers and dries up, as though it pines away, and soon becomes a bare trunk, unless the wise cultivator, perceiving what is the matter with it, detaches a sprig from the desired female and inserts it in the male, right in the middle of the medulla, called by some the heart of the palm***.

I must mention, however, that others have told me that, to fecundate the female, it is not necessary to insert those two or three branchlets of the male

*Dioscorides, Bk. 1, Cap. 127, quoted by MATTIOLI.—F.R.

**Theophrastus' sentence, in which he says that both male and female palms produce fruit, is not confirmed. Mattioli, in the first book of his discourse on Dioscorides falls into the same error.—F.R.

***See the address of TOURNEFORT to the Botanical Institute, chapter 69, where he confesses to not having found enough evidence to believe this.—F.R.

flowers into the female flowers: it is enough to dust the latter with a little of that white powder that falls from the male. If that were true, we could believe Pliny, who, writing of the palms, wrote:

*Adeoque est Veneris intellectus, ut coitus etiam excogitatus sit ab homine ex mariti flore, ac lanugine, interim vero tantum pulvere insperso feminis**.

That which many writers of fables have written of the palms corresponds with the foolish efforts of the Sicilians in their country in fecundating pistachios. These efforts are referred to by Father Don S. BACCONE in his *Museo di Fisica*, cap. 282. Experience shows in many places in Italy that the pistachio tree bears fruit as do other plants, without the fecundation, whose value is imaginary.

To Father ANTON SALVINI were shown by Signor B. GIROLAMI at his villa at Arcetri fine, new pistachio nuts but empty, owing, said Signor Girolami, to not having been fecundated by reason of the death of the neighbouring pistachio tree.

However this may be, when this operation of fecundating the female is done, the dates on the bunch are the size of pearls, and are at that stage very susceptible to damage by rain, which at all other times is of great benefit and should be frequent, and which is necessary for the growth and maturation of the dates. The dates, after the flower has fallen, are green but, when grown to the size of an olive, they begin to turn yellow, and little by little become, when ripe in the autumn, red. When the dates are red and mature on the tree, there sometimes drops from them a certain sweet liquid (as Pliny also notes), which thickens and which becomes granular like honey, whence arose the custom of removing the honey of this fruit artificially. For this purpose, at date harvest a large quantity of dates is put in a room provided with a marble floor, in the middle of which a channel is let in, leading to a small pit or basin. The honey oozes out of the mass of dates by itself and collects in the basin. This honey can be put to many of the uses of bees' honey†.

It is not only honey that may be obtained from dates. On the contrary, in many countries a certain beverage may be expressed from them which can be used as wine, and, just as wine is made both strong and weak, so this beverage can be found either sweet or insipid, and also sometimes rough, according to the variety of date from which it is made‡.

There is a place named Darà, seven days' journey south from Marrakesh, where are to be found dates, which are always green, both when unripe and when mature, bigger than others, and much better than them. When dried in the sun they become hard, and when bitten into they taste like sugar candy, whence their name, *Bu Sukri*, meaning ' Father of Sugar '‡†.

Another kind of dates is harvested at Tausar (Fr. *Tozeur*), a place in the Kingdom of Tunis, which is called Hura (*Hurra*), white in colour, with a very small stone, of exquisite flavour, not inferior to that of what are called

*P. ALPINO considers that this practice is necessary for fecundating the palms, whence he is constrained to maintain that, in the deserts of Arabia, the wind carries the fertilizing powder from the males to the females, which seems truly incredible and opposed to reason.—F.R.

†(Correct.—V.H.W.D.)

‡(I am not sure what is meant here. Perhaps the author is confusing *lagbi*, the sap of the palm, with *'araq*, the spirit distilled from dates.—V.H.W.D.)

‡†(If for ' green ' there be meant ' hard ' then this paragraph is correct. By Darà is probably meant the Waadi Dhira ', south of the Atlas mountains, called on the French maps Ould Dra.—V.H.W.D.)

Ftaimi (*Fatimii*), a much esteemed variety, whose dates, owing to their excellence, are sent as gifts to Constantinople. In Tunisia also is found a variety called Menacheirzeneib (*Menakhiir Zeinaab*), also good, but having the stone bigger than that of either *Fatiimi* or *Hurra*.

At Djerba are to be found dates called *Lemsi*, which even unripe are sweet, and have not that harsh bitterness which is characteristic of all other unripe dates†.

Indeed, the flavour of unripe dates is very rough and astringent or *strozzatoio* (choking), as the common people say. Pliny recounts how certain of Alexander the Great's soldiers, in the country of Gedrosia, were choked with eating unripe dates‡.

Other dates are found‡† black, and called Ammari (*Ammaari*), which, being very early, have a large sale.

In antiquity, a large quantity of dates were grown round Thebes in Egypt, which, although they were sour, dry, small, and, because of the continual heat, burnt up and having a bark rather than a skin, nevertheless were of much use in medicine, if we are to believe Dioscorides, GALEN, THEODORE PRISCIAN, GARIOPONTUS, and, from the poets, PAPINIUS STATIUS, who joking with his friend PLOTIUS GRIPUS, enumerated to him amongst the gifts that people used to send to one another at the Saturnalia, namely, *Chartae*, *Thebaicaeve**‡‡, *Caricaeve*.

I observe here in passing that in Statius dates are called *Thebaicae*, their proper name being omitted, as was common amongst the old Latin and Greek authors. Thus the Prince of Doctors, HIPPOCRATES, having to mention cummin, uses only the word *Etiopico*, as Galen says, in his *Glossary of Ancient Words* found in Hippocrates, *αἰθιοπικόν*, *ὑπακουστέον τὸ κύμινον*. Theocritus also in his *Fourteenth Idyll*, wishing to refer to that wine produced on the low hills of Castel Biblos in Coelesyria on the flanks of the Lebanon, called it simply *βύβλινος*. This was a very fragrant wine according to ARCHESTRATUS, quoting ATHENAEUS in his *Deipnosophistae*.

I think this way of speaking the writers have learned from those who sell fruit or such like, who are accustomed, when selling their goods, to enhance their desirability by giving them the name of the country in which they grow best.

I remember having read in CICERO that a certain BARULLUS, who had brought figs from Caunus for sale in the port of Brindisi, went about shouting at the top of his voice:—

*Cauneas, Cauneas. Cum Marcus Crassus exercitum Brundusii imponeret, quidam in portu caricas Cauno advectus vendens Cauneas clamitabat***.

†(For this reason these dates are the earliest on the market.—V.H.W.D.)

‡(STRABO (Bell, 1916, Vol. iii p. 123, sect. 7) states 'Many persons' (in Alexander's army on its way through Gedrosia) 'were suffocated by eating unripe dates'. On the previous page however we read 'The army was saved by eating dates and the marrow of the palm-tree. E. GAUBA[2] suggests that the palm whose fruit Alexander's soldiers ate must have been *Nannorhops ritchieana* H. Wendl., the low *mazari* palm or *piish* of Baluchistan. —V.H.W.D.)

‡†(In Tunisia, that is.—V.H.W.D.)

*Stat. 1.5. Selva ult. *Thebaicae* means *palmulae*, that is dates.—F.R.

‡‡(The author now seems to confuse the date with the fruit of *Hyphaene thebaica* Mart., the Theban or Duum Palm (Fr. *Doum*, Ar. *Daum*).—V.H.W.D.)

**Cicero. *De Divin.* I apprehend here a double meaning. The seller of Caunus dried figs cried *Cauneas*, as who should say *Cave ne eas*.—F.R.

I find also the same in Pliny, in the 15th book of the *Natural History:*

Ex hoc genere sunt, ut diximus, Coctana, et Caricae, quaeque conscendenti navem adversus Parthos omen fecere Marco Crasso venales praedicantis voce Cauneae.

I could copy out many other examples, were it not high time to cut short this excessively tedious digression and to return to palms.

Palms produce not only dates for food and medicine, but they also provide, similarly for food and medicine, that sweet, tender, white heart or marrow, which is found at the top of the stem, at the base of the fronds, as mentioned by Galen, Plutarch, ATHENAEUS, and PHILOSTRATUS. These said that it was called ἐγκέφαλος τῆς φοίνικος that is, brain of the palm. If this is cut off, the palm dries up and dies, as Abul Gheith several times told me. It must be mentioned, however, that Theophrastus and Pliny mention that there is a certain kind of palm, very different from the other, called Χαμαιρριφής which lives even though the brain is cut off, and buds out again close to the ground.

This palm, according to Theophrastus, Pliny, Mattiolo, CASTOR DURANTE, REMBERTO DODONEO, and GIOVANNI BAVINO, is often found in Crete, Spain, Mount Argentaro, and in Sicily, where, as in Naples, its brain retains nearly its original Greek name, being called *Cefaglione**.

On the other hand, the heart or brain of the date palm is called *Jummaar* by the Arabs; and, when Abul-Gheith mentioned the name to me, I called to mind that G. EMLACIN, an Arab author, wrote that a certain doctor administered the palm-heart to one of the Abbasids. Emlacin writes, according to Erpenius's translation:

Haronem Raschidum laborasse aliquando profluvio sanguinis, medicum autem suasisse esum Giummari palmarum;

and he adds:

Cum Giummarum Palmae edit, convaluisse.

The erudite TOMMASO REINESIO was quite incorrect when, explaining this passage from Elmacin, and endeavouring to specify what part of the palm is the *jummaar***, he states that it is the palm inflorescence before issuing from its spathe.

If, however, Reinesio has made a mistake, the ancient commentator on some of the Arab authors has done no less, for according to him, the *jummaar* is the medlar.

This same *jummaar* is what G. CHERMONESE, in the Latin translation of Avicenna, Lib. 2, cap. 359, called *Jumar*, and what A. ALPAGO in the notes called *Giemar*. In my opinion, the *jummaar*, as I have already suggested, is the same thing as that which the Greeks called ἐγκέφαλος τῆς φοίνικος ' the brain of the palm ', of which Plutarch in his *Dialogue on the Preservation of Health*, says that eating it gives one a headache.

The learned doctor T. Reinesio in his *Various Lessons* notices a serious error on the part of the translator of that particular dialogue of Plutarch, who because in Greek the word φοῖνιξ means both *palm* and *phoenix*, translating

*The *Chaemaeriphes* of Pliny, a small, low, recumbent palm, *Cefaglione* (big head), κεφάλιον is, in Latin, *Capitulum.*—F.R.

**Perhaps Reinesio thought that *jummaar* was from the Latin *gemmula.*—F.R.

into Latin the phrase ἐγκεφαλον τῆς φοίνικος, writes ' brain of the phoenix ' instead of ' brain of the palm.' The great Tertullian makes a similar mistake in his commentary on Psalm 92, δίκαιος ὡς φοῖνιξ ἀνθήσει (The just shall flourish as the palm), believing that David was speaking not of the palm but of the bird called phoenix; but what is worse is that he goes on to use the Scriptures as grounds for belief in the fable and uses the fable to persuade himself to believe in the profound mystery of the resurrection of the flesh. The truth of our blessed Faith does not need such frivolities and false bases; and I wonder greatly that the great Tertullian should have paid attention to such trifling. The Greek G. PISIDA also used the fable of the phoenix as support for the belief in the resurrection of the body at the end of the world*. Furthermore, Sig. DE DIGBI adduces the argument of certain crayfish fabulously reborn by means of their salt mixed with a prepared chemical. Enough, however, of this: it is not worth the time taken to confute such puerilities.

I must not forget to mention that there is a certain liquor which issues from the trunk of the palm, which round Tripoli is called *Aghibi*†, but the Arabs in other places usually call it *Haliib en-Nakhl*, that is date-palm milk, from its resemblance to milk both in colour and flavour.

In order to obtain the *lagbi* the fronds are stripped from the palm and the trunk is cut into in several places with a knife, and vessels are placed there to catch the liquor that oozes out. This liquor is refreshing and excellent for quenching the thirst, and is therefore widely used in medicine, more particularly for scalding urine. This tree milk little by little acidifies; and G. EUSEBIO NIEREMBERGIO states that the people of the Congo use it instead of vinegar†.

In that very hot country many kinds of palms are found, some of which bear dates from whose stones there is obtained a butter-like oil used for food and light. Another kind of palm, a wild one, grows only in the Congo, having fronds very suitable for being woven into mats, baskets and such like. From these fronds, macerated like our flax and spun, are made with great skill various kinds of cloth, some of which are as good as our plain and flowered velvets or our damasks. I remember having seen some of the strongest and most highly coloured pieces of this cloth given to His Serene Highness the Duke by some Capuchin fathers, who had returned from the Congo, and who stated that it was sometimes worn by the people of that place. A less important product, but perhaps one more worthy of regard, is the clothes woven out of coarse palms by the ancient solitaries in the holy caves of Nitria, Syria, and the Thebaid, in imitation of Paul the first hermit.

This is the information that, amongst much other, I have obtained from Khawaaja Abul Gheith. The rest I do not transcribe because it is easily

* The sages of antiquity held that the phoenix lived for about five hundred years, as DANTE affirms in cant. 24 of the *Inferno*, saying:

' Of the phoenix do wise doctors say
When its five hundredth year it do attain
It dies and is reborn '.—F.R.

† (Lagbi.—V.H.W.D.)

‡ (This must be the sap of another palm.—V.H.W.D.)

accessible in the works of the writers on natural history*, especially G. Bavino, who has dwelt at length on the palms.

Therefore, having nothing more to add I make Your Excellency a deep reverence, and remain

Your Excellency's Most Humble Servant,
Francesco Redi.

From his house, 1 May 1666.

(*Received December 1955*)

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* For a full account of the palms see the second book of the *Astrologia*, written by G. Pontadera, the celebrated lecturer in botany at the University of Padua.—F.R.

Staple Food Crops in West Africa and the Congo

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Although agricultural statistics for Africa are notoriously poor, they probably give a fairly good indication of the relative importance of the area devoted to various crops. The maps accompanying this article are a first attempt to describe the distribution of the major staple food crops in western tropical Africa. *Figure 1* for West Africa, including the French Cameroons, and *Figure 2* for the Belgian Congo identify staple food crop regions according to whether the position of dominant staple is assumed by millets and sorghums, rice, maize, plantains, or root crops. Where a secondary crop is also of substantial importance a composite classification is used such as ' rice and root crops '. The position of individual roots and tubers—manioc (cassava), yams, and coco-yams (taro)—is shown in *Figure 3* for those portions of West Africa where root crops are a major staple.

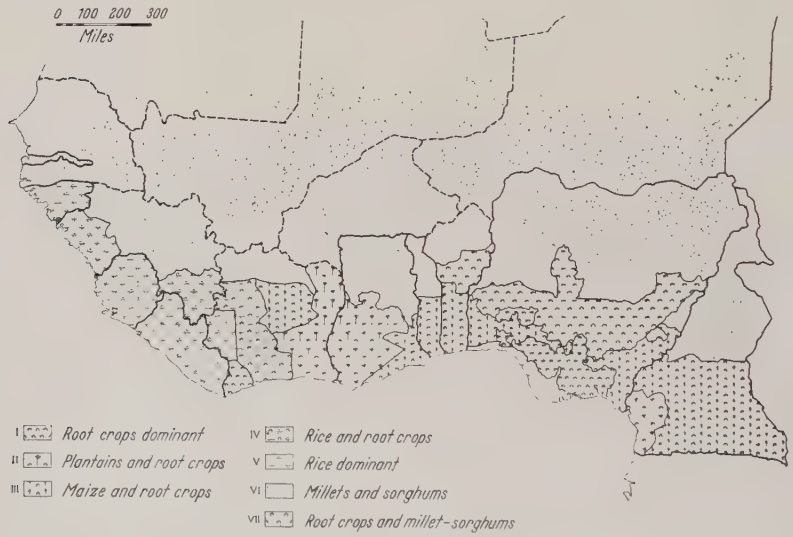

Figure 1. West Africa and the French Cameroons; staple food crop zones

The starchy staple food crops loom large in African diets, and measures directed at enlarging domestic food supplies or increasing agricultural productivity must inevitably concern themselves with these crops. The exaggeration is not great when a writer speaks of the ' rounded black pot that caters to hunger from one side of Africa to the other ' with its ' stodgy,

spiced, glutinous porridge that fills every belly from the Nile to the Zambesi'[1]. The starchy staple foods, the principle ingredients which go into that black pot, contribute approximately 85 per cent of the calorie intake in the savanna areas. In the forest regions, where palm oil is also a cheap source of calories, the starchy staples still account for about 65 to 75 per cent* of total food calories[3–6].

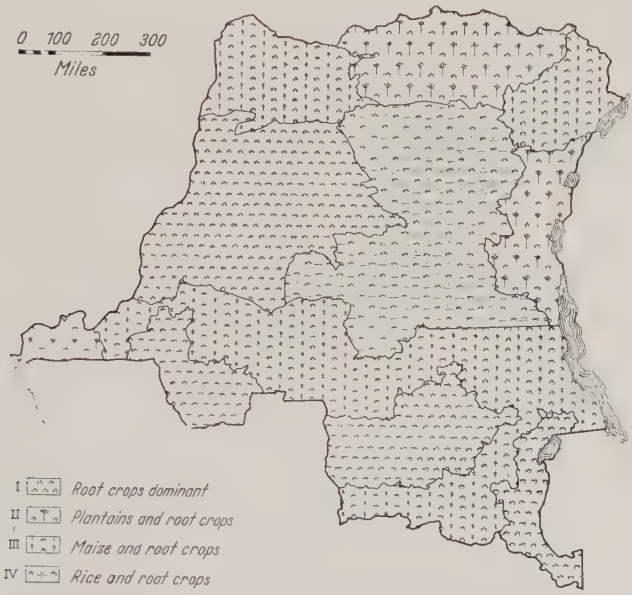

Figure 2. Belgian Congo; staple food crop zones

In contrast with monsoon Asia, where rice alone is of such pre-eminent importance, in tropical Africa there is a great deal of regional variation in the crops which assume the role of major staple. Something of the complexity of the staple food pattern is shown in *Figures 1* and *2*. But these maps, because they present generalized areas, conceal much local variation. Moreover, specialized producion of a single crop is rare in tropical Africa, and mixed planting of, for example, yams, maize, and beans is exceedingly common. Use of the omnibus category ' root crops ' conceals variations in the position of individual roots or tubers; but *Figure 3*, showing the position of individual root crops in West Africa, overcomes that deficiency in the area where variation in the dominant root crop is most marked.

In West Africa, only two large, continuous crop regions are discernible. The millet–sorghum region dominates the huge savanna belt stretching across the continent north of a line between 8° and 10° N. Lat.; it represents an area far larger than that occupied by any other crop in West Africa—nearly nine million hectares if we can believe the published estimates. It is to be noted, however, that this region embraces not only two major

* The comparable percentages for 40 countries and a scatter diagram showing the correlation (inverse) of these ' starchy staple ratios ' with per capita national incomes are provided by M. K. Bennett.[2]

crops—bulrush millet (*Pennisetum typhoideum*) and Guinea corn (*Sorghum vulgare*)—but a number of minor cereals as well*.

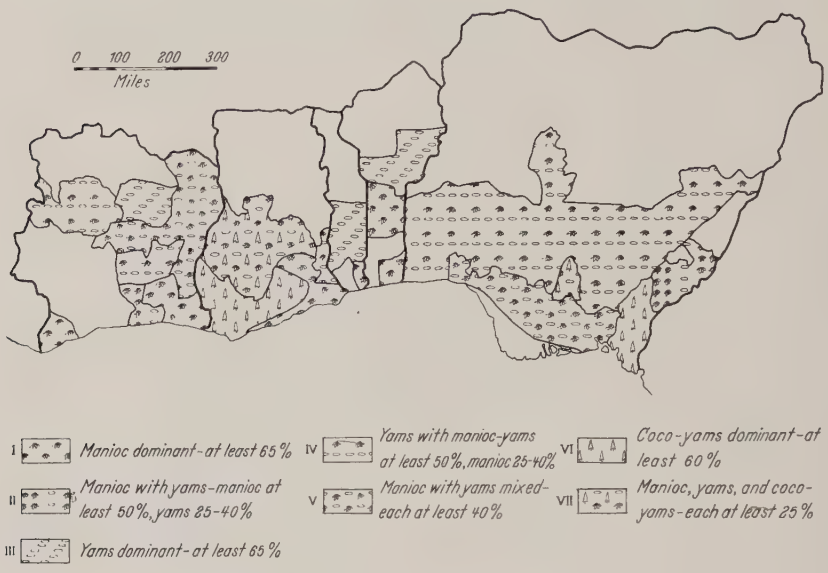

Figure 3. West Africa, distribution of root crops

The rice region which stretches south along the coastal zone from the Gambia to the Bandama River in the centre of the Ivory Coast is the other large, continuous area. Actually, Gambia and the Casamance area (Ziguinchor *cercle*), which is the southern extension of Senegal, are not rice-dominant. They lie to the north of the heavy rainfall belt centring on Liberia, and in the Gambia rice occupies only about a fifth as much land as the drought-resistant millets and sorghums; in the Casamance area, more than half as much land is devoted to rice as to millet and sorghum. In the wet belt of forest and savanna bush to the south, rice is clearly dominant, but root crops are often of appreciable importance. In fact, several of the *cercles* of the Ivory Coast are classed as rice and root crops since the roots are an important secondary crop *i.e.* occupy an area at least 40 per cent as large as is devoted to rice. Tabou *cercle* in the southwestern corner is conspicuous as an enclave where manioc is dominant by a large amount. Eastward along the Guinea coast from the mouth of the Bandama, rice ceases to be a major or secondary crop. In a region extending some two or three hundred miles inland and including the western half of the Ivory Coast, the Gold Coast, Togo, Dahomey, and Nigeria, manioc, yams, plantains, maize, or coco-yams are alternatively the major or secondary crop.

The distribution in the French Cameroons is similar to that of crops in West Africa. Millets and sorghums are dominant in the north, and root crops, maize, and plantains are the principal staples in the southern half of the territory. Some contrasts with West Africa are to be noted in the case of

* *Pennisetum typhoideum* and *Sorghum vulgare* are composite names commonly used to designate bulrush millet and Guinea corn. J. M. DALZIEL[7] lists the individual species cultivated in West Africa. Of the minor cereals included in the millet-sorghum group, *Digitaria exilis* (*fonio*, 'hungry rice', *acha*) and *Eleusine coracana* ('finger millet', *tamba*) are probably the most important.

the Belgian Congo (see *Figure 2*) where there is no large millet–sorghum area and where yams are of slight importance. Manioc is the chief staple in the Congo by a wide margin with maize ranking second. Rice is an important secondary crop, and in two of the districts classed as rice and root crops—Stanleyville and Sankuru—the rice area is slightly larger than the area planted with manioc.

French Equatorial Africa is not shown on the accompanying maps. Crop data by territory, the only breakdown which appears to be available, indicates that Chad territory in the north is in the millet–sorghum belt. According to descriptive material, the northern part of Oubangui-Chari is also within the millet–sorghum zone, but manioc is dominant in the territory as a whole. In the two southern territories, Gabon and the Middle Congo, plantains, manioc, and coco-yams are the chief staples. Crop data for Angola are even more limited, although it is clear that maize and manioc are the major crops*.

One of the distinctive features of the whole area considered is the exceptional importance of root crops. Although the roots and tubers occupy a much smaller area in West Africa than millets and sorghums, they probably contribute a greater share of the total food calories consumed, owing to their high yields per acre. Manioc and yams, each of which occupies about one-fifth as much land as the millets and sorghums, are the chief root crops; but coco-yams and sweet potatoes are important in some districts (see *Figure 3*). In the Belgian Congo, manioc alone accounts for some 40 per cent of the total area planted to staple food crops. Sweet potatoes rank second in the root and tuber category in the Congo but cover only about one-tenth as large an area as manioc.

An understanding of the distribution of the staple food crops is significant in several ways. Differences among the crops with respect to the conditions of production, yields per acre, nutritive content, storability, and transport characteristics are of considerable importance. It is commonly stressed, for example, that wet rice is unique among the cereals in that it lends itself to continuous cultivation in tropical areas, whereas with other crops the land must be rested under a bush fallow to restore fertility after a few years cultivation†. Millets and sorghums, and in a lesser degree maize, differ from other cereal crops in their ability to survive periods when soil moisture reserves are depleted by going into a dormant period and then resuming growth if later rains arrive. Among the roots and tubers, manioc possesses this type of drought resistance to a marked degree.

Manioc is also outstanding for its high yield per acre, some three or four times as high as for the cereal crops even in terms of calories. Yields of manioc tend to be considerably higher than for yams, especially when yam yields are considered net of the substantial seed requirements for that crop.

* G. L. Lefebvre[8] gives production estimates for these and other crops and H. L. G. Abreu Velhoa[9], presents maps which show the distribution of staple food crops in Angola. One of these indicates that manioc is dominant in the north and northeast, that maize is the chief crop in a large central zone lying east of Luanda and Benguela, while millets and sorghums prevail in the arid region to the south.

† This is of more potential than present significance. Cultivation of upland rice seems to be much more extensive than wet rice despite the widespread efforts to promote the latter, notably in Sierra Leone, the Ivory Coast, French Guinea, and Liberia. Controlled irrigation of rice is quite limited, the Office du Niger project in the French Sudan and Richard-Toll in Senegal being the principal examples. But there is some bunding in connection with 'swamp rice' cultivation, as in Sierra Leone, to control salinity and sometimes partially to control the flow of water over rice land when the river floods and subsequently when it subsides. Floating rice is found in a few areas, for example in parts of the inner delta of the Niger where riverine areas slowly flood to a depth which would drown ordinary rice.

Where soils are poor or mediocre, for example because of fairly intensive cropping, this yield advantage of manioc is particularly noteworthy. Another characteristic of manioc which is of some interest is that the cuttings can be planted and allowed to grow to maturity with very little effort, whereas harvesting the roots involves much labour. Hence, a sizable fraction of the crop is frequently left unharvested if the family does not need additional food or if the prevailing price is not considered sufficiently attractive. This peculiarity of manioc production would appear to cast some doubt on assertions which have been made in recent discussions of African development concerning ' the inelasticity of domestic food supplies '[10, 11], at least in areas where manioc is the chief staple.

The root crops, particularly manioc, are much inferior to the cereals as a source of protein and of vitamins of the B complex. Hence the availability of those nutrients in supplementary foods such as beans, fish, or meat may be of crucial importance where root crops supply a high percentage of total calories. In contrast with the root, manioc leaves are a rather good source of protein and the B vitamins (and also vitamin A and calcium). It would be desirable to know how commonly the leaves figure as an important item of diet, but information on that point is scanty.

The present pattern of distribution of the staple foods, and information relative to the requirements and characteristics of these crops, also seems relevant to the task of evolving improved farming systems in the various regions of tropical Africa. C. E. Kellogg, in a study of African soils[12], has stressed the need for fundamental and applied research to provide ' a basis for new inventions in soil management,' capable of realizing ' the great potentialities of tropical soils '. Writing of tropical agriculture in general, A. L. Jolly has recently underlined the importance of devising improved management systems based upon accumulating knowledge with respect to crop rotations, fertilizer use, and mixed farming[13]. A similar emphasis on the need to progress from ' cultivation ' to ' farming ' is found in the *Report of the Agricultural Productivity Committee* in Uganda which declares that ' although a great deal has been done to improve methods of cultivating particular crops ' there has been comparative neglect of ' problems of African farm management, economics and farm layout . . .'[14].

The nature of the most efficient and profitable changes in African systems of farming can hardly be suggested here; in Kellogg's words they ' remain to be invented '[12]. Jolly and the Uganda group suggest that a major feature will be incorporation of livestock into mixed farming; and for some years there has been progress in that direction in the Northern Territories of Nigeria and the Gold Coast and elsewhere in West Africa. While expansion of mixed farming seems probable as a long-term trend, the slow growth of consumer purchasing power and the difficult and costly task of tsetse control probably preclude any rapid progress in that direction. Efforts to evolve more systematic and scientific agricultural systems in the *paysannats indigènes* of the Belgian Congo have obtained promising results with rotations combining native food and industrial crops[15–18]. Whatever systems of farming may emerge, it is certain that some or all of the starchy staples which now form so large a part of African food supplies will figure prominently as human food or as feed for livestock.

Finally, it is appropriate to stress that information about the distribution of the staple food crops also provides considerable information about dietary patterns. Since movements of staple foods over considerable distances are of small importance in tropical Africa, there is necessarily a rather close correspondence between the patterns of consumption and production.

The maps presented and these brief comments suggest more questions than they answer. What are the factors—natural, historical, and economic—which underlie the present pattern of distribution of the staple food crops ? What are the changes in the pattern to be expected with further economic development ? Will specialized centres of commercial production emerge with the growth of demand as a consequence of urbanization, industrial development, and increase of population ? Will the root crops decline in importance as their perishability and bulkiness become important cost factors at the retail level ? Are African consumers likely to turn increasingly to rice and wheat, foods which have been regarded elsewhere as ' preferred cereals ' ? Will manioc continue to expand, favoured by its high yield and the moderately good storage and transport characteristics of manioc in the form of meal (*gari*) or flour ? What is the prospect for maize, another New World crop which is far from having achieved the commanding position it holds in the hot regions of the western hemisphere ? The study from which this note is drawn is primarily concerned with the first question—the factors underlying the existing pattern of distribution of the staple food crops[19]. Some attention is being given, however, to recent trends affecting the position of the major staples and the evidence, fragmentary though it is, which points to changes in the future pattern of consumption.

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APPENDIX

The maps are in general based on a classification of administrative subdivisions according to official statistics of crop area made about 1950. No breakdowns of crop data are available for Liberia, Sierra Leone, Portuguese Guinea, and the French Sudan (except for rice production). For most of French West Africa crop area statistics by *cercle* were utilized. In the Ivory Coast the classification is based on data for six agricultural sectors although two of these have been split on the basis of data by *cercle* kindly made available by M. J. Miège, Institut d'Enseignement et de Recherches Tropicales, Abidjan/Adiopodoumé; and the root zones of *Figure 3* are based on data by *cercle*. The classification in Nigeria is based on data pertaining to the 14 agricultural zones used in the 1950 sample census of agriculture. It should be pointed out that the classification of Bamenda district, British Cameroons, in *Figure 3*, is questionable. According to the sample census data it should have been described by an eighth category, ' Manioc with coco-yams '. In the portions of Bamenda studied by P. M. KABERRY, however, coco-yams appear to be the dominant root crop, and her report suggests that yams are more important than manioc. *Women of the Grassfields: A Study of the Economic Position of Women in Bamenda, British Cameroons*, p. 20, *Col. Res. Publ.* No. 14 (London: H.M.S.O. 1952). Crop statistics for a grouping of *cercles* into five regions was the smallest breakdown available for the French Cameroons. The classification in the Belgian Congo is based on area figures for the 20 administrative districts. Territorial boundaries have been retained, but otherwise boundary lines within a common crop region have been omitted. Comments on possible errors in the maps will be very much appreciated.

Crop data were taken from: Belgium, Ministry of Colonies, *L'Agriculture au Congo Belge et Ruanda Urundi 1948 à 1952* (Brussels, 1954); Ministrie de la France d'Outre-Mer, *Ann. Stat. de l'Union Francaise 1939–46, Chap. F.* (Paris, 1949); Haut Commissariat de l'Afrique Occidentale Française, *Ann. Stat. de l'Afrique Occidentale Française, Vol. II* (Paris, 1951); Gold Coast, Department of Agriculture, *Annual Report . . . 1st April 1952 to 31st March 1953* (Accra, 1954); Nigeria, Department of Statistics, *Report on the Sample Census of Agriculture 1950–51* (Lagos, 1952); *Ager*, Boletin de la Direction de Agricultura de la Guinea Española, Vol. 4, Jan.–June 1954; *Annuario da Guiné Portuguesa 1948* (Publicaçao do Governo da Colónia, Lisbon). Data for Sierra Leone and Liberia respectively were taken from *Report on the 1950 Census of Agriculture, Vol. 1* (F.A.O. Rome, 1955) and *Yearbook of Food and Agriculture Statistics 1954* (F.A.O. Rome, 1955). Data by *cercle* were kindly made available by M. Thomas of the Dahomey territorial government and for the Ivory Coast by M. J. Miège.

Seasonal Variation in Attack by Diatraea *spp. on Sugar Cane in Trinidad*

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During the course of several years' investigations of the parasites of *Diatraea* spp. in Trinidad it became obvious that neither attack by *Diatraea* nor the degree of larval parasitism by *Paratheresia claripalpis* Wulp. or *Agathis stigmaterus* (Cress.) was uniform throughout the year. The relative proportions of the species of *Diatraea* attacking sugar cane in Trinidad have undergone a considerable change in the last ten years or more, *D. saccharalis* F. now being very much more important than it was formerly. The change appears to have been due to the utilization of newer cane varieties and probably not, as has been suggested, to the use of modern insecticides for the control of froghopper, *Aenolamia varia* (Dist.).

In general the seasonal trend of *Diatraea* spp. in sugar cane is as follows. Young canes, planted usually between June and December, produce shoots which become infested with a population of borer larvae, predominantly *D. saccharalis*, but including some *D. impersonatella* Wlk. and *D. canella* Hmps. With growth a number of the shoots develop into canes and there is an increase in the proportion of *D. canella*, with a corresponding decrease in that of *D. saccharalis*. There is a slight increase in the proportion of *D. impersonatella* but this is not so large as that of *D. canella*; towards crop time the proportion of *D. canella* may be very high.

After crop, first ratoon shoots from the same stools are attacked mainly by *D. canella*, the other two species being very much less common. In general *Diatraea* attack is lower in young ratoons than in plant canes.

Diatraea larvae in the cane are attacked by several species of parasites of which the most important in Trinidad is *Paratheresia claripalpis*. *Diatraea saccharalis* is the host in sugar cane from which this parasite is most commonly reared, it occurs less frequently in *D. impersonatella* and is a very rare parasite of *D. canella*. Parasitism by this species appears to increase during the dry season reaching a maximum in April and May, and to decrease with the coming of the rains, probably due to the cumulative action of a hyperparasite *Trichopria cubensis* Fouts. attacking the Tachinid puparia[1]. This seasonal difference in parasitism and effect of *Trichopria* is very variable from year to year.

The Braconid *Agathis stigmaterus* attacks all three species of *Diatraea* but is usually of comparatively little importance as a control, although at times it has been found to parasitize up to 30 per cent of the larvae in an individual field. This species is usually more common between January and March.

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Leskiopalpus (*Stomatodexia*) *diadema* Wied. is a parasite principally of *Diatraea canella* though it is found occasionally in the other species. Although it occurs in most parts of the island it is more common in the southern sugar growing areas. No records have been kept of any seasonal variation. At the beginning of the rainy season (June) a number of larvae, in individual collections up to 20 per cent, are killed by a species of parasitic nematode.

Relative proportions of the three *Diatraea* species, and of parasitism are given in *Tables 1* and *2*. The collections were made[1] from two areas in the same general region, but in *Table 1* the principal cane variety grown was B.37161 and in *Table 2* the principal variety was B.34104.

Table 1. Collections of full-grown Diatraea *larvae from Woodford Lodge Estate; 15 July to 31 October, 1948*

	D. saccharalis	D. impersonatella	D. canella
Number of larvae	11,247	1,231	1,185
Percentage	82·3	9·0	8·7
Parasitism %			
Paratheresia claripalpis ..	14·3	5·8	0·0
Agathis stigmaterus ..	0·8	2·3	0·1
Leskiopalpus diadema ..	0·0	0·0	0·7

Table 2. Collections of Diatraea larvae from Caroni Estate—Frederick section; 1 July to 30 September, 1948

	D. saccharalis	D. impersonatella	D. canella
Number of larvae	248	2,463	2,627
Percentage	4·6	46·1	49·2
Parasitism %			
Paratheresia claripalpis ..	10·8	5·6	0·4
Agathis stigmaterus ..	0·0	1·7	0·4
Leskiopalpus diadema ..	0·0	0·0	0·0

With these indications of varietal and seasonal differences in the *Diatraea* complex it was thought worth while attempting to investigate these factors in greater detail.

METHODS

In order to obtain samples of *Diatraea* larvae for laboratory examination and rearing, two fields of plant sugar cane were selected at the Agricultural Station at Centeno, one of B.37172 the other of B.4098, the only varieties present in fields of suitable size and age of cane. Mass collections of *Diatraea* larvae, pupae, and parasite puparia and cocoons were made regularly in each field from May 1953. This material was sorted and each individual was placed in a separate glass vial, the larvae being kept supplied with pieces of fresh sugar cane. The emergents from these, moths and parasites, are recorded in *Table 3*.

In August an additional two fields were sampled, the procedure being slightly modified. A number of two foot long plots in a cane row were cut out completely and the number of canes and shoots recorded in addition to all the stages of *Diatraea* and parasites. This gave a quantitative figure for the numbers of borers and parasites in a known length of cane row and

hence the numbers per acre could be estimated. These results, grouped monthly according to the date of sampling, are given in *Tables 3* and *4*.

Table 3. B.4098. Results of samples of Diatraea *material taken at Centeno in 1953: fields 1 & 2 sampled qualitatively only; field 9 sampled quantitatively*

Month	Fields 1 and 2					Field 9						
	D. saccharalis *large larvae* %	D. impersonatella *large larvae* %	D. canella *large larvae* %	Parathersia %	Parathersia *puparia parasitized by* Trichopria %	*Tillers per acre* × 1000	*No. canes per acre* × 1000	*Total Borers per acre* × 1000	D. saccharalis *large larvae* %	D. impersonatella *large larvae* %	D. canella *large larvae* %	*Full-grown* D. saccharalis *parasitized by* Parathersia %
1953												
May	71·4	7·0	21·6	11·4	75·7	—	—	—	—	—	—	—
June	48·6	15·5	35·9	17·0	52·5	—	—	—	—	—	—	—
July	21·8	25·5	52·7	10·8	28·6	—	—	—	—	—	—	—
Aug.	31·7	45.3	23·0	5·1	28·6	9	54	10·4	85·4	3·8	10·8	11·9
Sept.	27·6	32·4	39·9	12·1	0	1	49	15·1	69·1	6·8	24·1	4·9
Oct.	20·2	34·6	45·1	4·4	16·7	5	44	12·9	60·8	7·4	31·7	1·7
Nov.	11·9	26·5	61·6	2·9	40·0	1	43	8·7	53·7	9·5	36·8	6·9
Dec.	15·0	22·5	62·5	2·9	40·0	2	23	9·5	36·9	12·5	50·5	2·9
1954												
Jan.	16·4	20·0	63·5	1·3	20·0	—		–	—	—	—	—

In 1954 sampling was continued using this method but in addition the number of shoots and canes attacked by *Diatraea* were recorded. However, these samples were not taken in fields, but in specially planted plots of five varieties: BH. 10/12, B.3337, B.37161, B.37172 and B.4098. Each plot consisted of a single bed of four cane rows and there were six replicates of the five sets of plots. Results from these samples were grouped as before and are recorded in *Tables 5* to *9*. These plots were planted between 8 and 26 September 1953 and supplied in October.

Table 4. B.37172. Results of samples of Diatraea *material taken at Centeno in 1953–54: fields 1 & 2 sampled qualitatively only; field 9 sampled quantitatively*

Month	Fields 1 and 2					Field 9						
	D. saccharalis *large larvae* %	D. impersonatella *large larvae* %	D. canella *large larvae* %	*Full-grown* D. saccharalis *parasitized by* Parathersia %	Parathersia *puparia parasitized by* Trichopria %	*Tillers per acre* × 1000	*No. canes per acre* × 1000	*Total Borers per acre* × 1000	D. saccharalis *large larvae* %	D. impersonatella *large larvae* %	D. canella *large larvae* %	*Full-grown* D. saccharalis *parasitized by* Parathersia %
1953												
May	89·8	2·1	8·1	11·9	57·4	—	—	—				
June	33·7	12·0	54·3	13·4	66·7	—	—	—	—	—	—	—
July	25·9	7·1	67·0	13·9	0	—	—	—	—	—	—	—
Aug.	—	—	—	—	—	11	61	11.0	75·0	1·7	23·3	17·8
Sept.	28·7	29·4	41·9	7·1	18·2	—	—	—	—	—	—	—
Oct.	28·9	25·5	45·5	5·4	10·0	12	44	11·1	56·1	5·4	38·5	7·3
Nov.	14·1	25·9	60·0	8·3	20·0	1	42	12·6	67·6	3·0	29·4	5·5
Dec.	—	—	—	—	—	1	53	14·6	39·7	4·2	56·1	6·2
1954												
Jan.	6·5	37·4	56·1	0	0	2	45	10·6	29·0	16·1	54·8	0

In this last experiment sampling continued from the time that the plants started forming canes, in January and February, until October when the cane was beginning to reach maturity. It was planned to try to correlate

final figures for the infestations of the cane with yields and laboratory analyses of sugar content *etc.* However, this was impossible as the field was accidentally burned just before it was due to be cut.

Table 5. BH. 10/12. Results of samples of Diatraea *material taken from experimental plots at Centeno 1954*

Month	*Tillers per acre* × 1000	*Tillers bored by* Diatraea %	*Cane per acre* × 1000	*Cane bored by* Diatraea %	*Total Borers per acre* × 1000	D. saccharalis *large larvae* %	D. impersonatella *large larvae* %	D. canella *large larvae* %
Feb.	31	—	17	—	3·5	84·4	3·8	11·8
Mar.	—	—	—	—	—	—	—	—
April	17	13·6	11	32·2	1·4	55·6	—	44·4
May	17	26·7	23	15·0	1·1	38·5	15·4	46·1
June	13	38·7	21	18·3	0·9	83·3	8·3	8·3
July	12	25·4	34	23·2	1·8	36·8	21·1	42·1
Aug.	12	18·3	38	21·1	1·2	42·1	15·8	42·1
Sept.	14	18·2	42	44·1	3·1	—	25·0	75·0
Oct.	13	30·5	42	40·0	5·0	11·7	15·6	72·7

Table 6. B.3337: Centeno 1954

Month	*Tillers per acre* × 1000	*Tillers bored by* Diatraea %	*Cane per acre* × 1000	*Cane bored by* Diatraea %	*Total Borers per acre* × 1000	D. saccharalis *large larvae* %	D. impersonatella *large larvae* %	D. canella *large larvae* %
Jan.	35	—	22	—	6·2	94·7	—	5·3
Feb.	36	—	26	—	3·5	85·7	3·6	10·7
Mar.	36	—	36	—	2·0	63·6	9·1	27·3
April	35	23·3	45	31·4	3·8	88·1	5·9	5·9
May	24	25·7	43	22·2	3·5	81·7	1·7	16·6
June	10	38·5	42	26·2	4·9	78·0	9·5	12·5
July	5	30·5	46	32·5	4·0	62·5	7·5	30·0
Aug.	4	14·1	44	36·9	2·6	38·2	2·9	58·8
Sept.	8	3·7	44	36·2	2·2	31·9	4·5	63·6

RESULTS

Since the results obtained in 1954 are more complete than those for 1953 they will be considered first. Each column of *Tables 5* to *9* will be compared separately before a general discussion is made of these and the results of the previous year.

Shoots per acre

From sugar cane plant material a number of shoots soon spring up after planting and it is from these and others developing subsequently that canes are formed. When a number of these young shoots are killed by *Diatraea* (or by *Castnia licoides* Boisd.) it is important from the point of view of cane yields and sugar production to know how many shoots survive and how quickly the dead ones are replaced by new growth. The first column of *Tables 5* to *9* shows how, under these particular growth conditions, the varieties examined differed in the number of shoots produced initially, the rate at which these developed into canes, and the production of shoots during later growth.

BH. 10/12—Under these conditions this variety produces fewer shoots and canes at the beginning of the growing season than the other varieties and these shoots are slower to develop into canes. However the number of shoots relative to the number of canes remains high throughout the period.

B.3337—Many shoots are produced in the early stages of growth and these develop quickly into canes. At the end of May, the beginning of the wet season, production of shoots almost ceases and most of those which have not produced canes apparently die off.

B.37161—There is a similar high production of shoots initially but fewer additional shoots are produced later. The development of the early shoots to cane is faster than in the previous variety and takes place even during the dry season. There are few shoots present from May onwards.

Table 7. B.37161: Centeno 1954

Month	*Tillers per acre* × 1000	*Tillers bored by* Diatraea %	*Cane per acre* × 1000	*Cane bored by* Diatraea %	*Total Borers per acre* × 1000	D. saccharalis *large larvae* %	D. impersonatella *large larvae* %	D. canella *large larvae* %
Jan.	25	—	26	—	8·4	100·0	—	—
Feb.	22	—	20	—	5·3	100·0	—	—
Mar.	13	—	35	—	5·1	57·2	7·1	35·7
April	16	34·8	37	46·8	7·2	94·0	—	6·0
May	7	55·5	35	46·3	4·0	96·7	—	3·3
June	3	33·9	35	49·9	6·7	95·1	1·6	3·2
July	4	10·8	41	51·2	3·8	45·2	2·4	52·4
Aug.	4	4·9	40	48·5	2·3	54·1	2·7	43·2
Sept.	8	7·2	48	59·6	4·5	17·0	6·4	76·6
Oct.	4	—	37	44·6	0·7	—	—	100·0

B.37172—There is a very rapid production of canes from shoots even at the beginning of the dry season. Apparently a number of these shoots and also young canes die off leaving a smaller number (about 45,000) of canes per acre, similar to the figure for the other varieties.

Table 8. B.37172: Centeno 1954

Month	*Tillers per acre* × 1000	*Tillers bored by* Diatraea %	*Cane per acre* × 1000	*Cane bored by* Diatraea %	*Total Borers per acre* × 1000	D. saccharalis *large larvae* %	D. impersonatella *large larvae* %	D. canella *large larvae* %
Feb.	33	—	49	—	9·0	87·7	—	12·3
Mar.	24	—	49	—	4·3	68·8	—	31·2
April	24	41·9	63	39·0	8·8	91·7	1·4	6·9
May	13	56·4	45	36·8	6·2	88·7	2·6	8·7
June	5	34·4	41	32·7	3·8	70·4	11·1	18·5
July	5	18·8	45	38·5	2·7	46·2	3·9	49·9
Aug.	3	4·6	41	54·8	2·3	16·3	6·1	77·6
Sept.	7	12·5	46	39·8	2·3	21·9	9·4	68·7
Oct.	6	10·5	51	44·5	3·1	—	—	100·0

B.4098—Somewhat fewer shoots and slower to form canes than the previous variety. Excess shoots dying somewhat later.

Thus in all varieties a far larger number of shoots is produced than eventually form canes. Hence a moderate attack by *Diatraea* on the shoots may probably not affect the subsequent yield of canes, although it is important in maintaining and increasing the *Diatraea* population.

Table 9. B.4098: Centeno 1954

Month	*Tillers per acre* × 1000	*Tillers bored by* Diatraea %	*Cane per acre* × 1000	*Cane bored by* Diatraea %	*Total Borers per acre* × 1000	D. saccharalis *large larvae* %	D. impersonatella *large larvae* %	D. canella *large larvae* %
Feb.	33	—	31	—	7·8	83·3	6·1	10·6
March	34	—	33	—	2·9	63·1	10·6	26·3
April	23	15·6	34	22·0	3·8	66·7	33·3	—
May	23	45·5	45	36·6	6·5	83·3	4·4	12·2
June	16	61·8	39	37·6	3·1	91·9	5·2	2·7
July	9	20·4	36	46·3	2·6	40·6	11·6	47·8
Aug.	6	24·8	38	50·4	1·7	22·2	11·1	66·7
Sept.	7	14·1	40	35·7	2·6	13·5	8·1	78·4
Oct.	8	11·3	48	57·7	3·2	4·0	8·0	88·0

Canes per acre

This has been referred to in the previous section. The final number of mature canes per acre is similar in all these varieties, BH. 10/12 being apparently somewhat lower than the others. However the rates of development of these canes and hence the time during which they are susceptible to *Diatraea* attack are different. BH. 10/12 develops canes very much more slowly than the others, B.37172 being the fastest.

Degree of attack by Diatraea

From April 1954 onwards an estimate was obtained, not only of the total number of borer stages per acre, but also of the percentage infestation of shoots and canes. The intensity of attack and seasonal variation are similar in BH. 10/12 and B.3337 and these two varieties are the least attacked. With BH. 10/12 the actual number of shoots present per acre is about the same throughout the growing period, but in B.3337, and the other varieties used, there are very many more shoots earlier in the season which either produce canes or die off later. Thus the *Diatraea* population in the cane shoots was actually higher in B.3337 than in BH. 10/12 in the earlier part of the year, owing to the greater number of shoots in the latter variety, but from August onwards it was considerably less.

With the other varieties there is heavy attack on shoots when they are plentiful in April to June (with a maximum of 61·8 per cent attack in June on B.4098), but the attack declines as the season advances.

With regard to the proportion of canes attacked it is obvious that in April to August, the period of rapid growth of the cane, there is with B.10/12 a lighter attack on the canes than with the other varieties. B.3337 is the next lowest, followed by B.4098 and B.37172, with B.37161 the most heavily attacked.

As the cane matured however, B. 10/12 appears to have suffered an increase in attack while figures for the other varieties remain about the same.

These figures for attack on nearly mature cane represent largely the result of earlier attacks, since as seen below numbers of living *Diatraea* present decrease as the cane matures.

Numbers of Diatraea *per acre*

Apart from the variation in degree of attack on different varieties of cane it was felt desirable to obtain an estimate of the actual total numbers of all stages of living *Diatraea* spp. present per acre, since this represents, with an allowance for parasitism, *etc*, the total potential damaging force of *Diatraea* at any time.

Although the population showed considerable variation between January and October it was not possible to correlate these variations with any definite generations of borer. Population was high in all varieties in January and February, declined in March, was generally higher in April to June and declined after this. In BH. 10/12 there appeared to be an increase towards the end of the sampling period.

From these figures it is seen that, compared with the other varieties, BH. 10/12 has a consistently low population except in September and October. B.37161 is consistently high in this regard except in October, and although the living population in this variety is then low the accumulated damage from earlier attacks is heavy. B.37172 is comparable with B.37161 in the earlier months until May and the population then declines somewhat below that of the latter variety. B.3337 supports a large population in January, this decreases below average in February to May and then increases considerably in June to August.

The highest figure, that for B.37172 in February, is 9,000 *Diatraea* stages per acre. The lowest, B.37161 in October, is 700 per acre (a figure based on very small samples). The average over the period for all varieties is 3,800. Since variation from month to month occurs independently in each variety this last figure does not mean very much, nor do the figures for the average numbers per acre for each variety for the whole period which are: BH. 10/12 2,200, B.3337 3,600, B.4098 3,800, B.37171 4,700, B.37161 4,800. These do however give some idea of the susceptibility of the different varieties to *Diatraea* attack and confirm the general observations that B.37161 is a most susceptible variety in Trinidad and BH. 10/12 is least attacked.

It should be stressed that these figures taken from a small area of experimental plots in one locality from canes planted at one definite time may not give results of general application. Other experiments in different areas and with different planting times must be carried out to confirm this.

Species of Diatraea *present*

In connection with the foregoing figures on the *Diatraea* population it is important to know what variation, seasonal and varietal, there is in the species complex of *Diatraea*. For this purpose a single age-group of *Diatraea* —that of three-quarters to full-grown larvae—was separated into species and these recorded separately (see *Tables 5* to *9*).

Here again the differences between BH. 10/12 and B.37161 were noteworthy. In the early part of the year the proportion of *D. saccharalis* in the

total mature larvae from BH. 10/12 was high (84·4 per cent) compared with 100 per cent for B.37161. In BH. 10/12 this figure dropped more quickly with time than in B.37161. (The June figures for BH. 10/12 are based on very small numbers.) In BH. 10/12 in young canes the proportion of *D. canella* is greater than in other varieties. In B.37161 there was a gradual change with age of the cane from 100 per cent *D. saccharalis* to 100 per cent *D. canella* (again the October figure for this is somewhat unreliable owing to the small numbers involved) and *D. impersonatella* was at no time important. In BH. 10/12 there was a very much greater proportion of *D. impersonatella* and the change with ageing of the cane between the other two species was very much less marked.

The other varieties are intermediate in this regard, with B.37172 coming closest to the B.37161 pattern.

These variations in the structure of the species complex are very important in connection with biological control since larval parasitism of *D. saccharalis* is very much higher than in the other two species.

As was pointed out above there has in recent years been a considerable change in the importance of each species of *Diatraea* in Trinidad, and it has seemed possible that the change was due principally to an increase in the numbers of *D. saccharalis* without a correspondingly large increase in the numbers of the others.

Some support is given to this idea by the figures obtained here. For the period January to May inclusive the *D. saccharalis* in the total collections of large larvae from B.37161 and BH. 10/12 was 89·6 per cent and 59·5 per cent respectively. If the populations of the other two species were numerically the same in the two varieties then these figures would indicate a numerical increase in the *D. saccharalis* population in B.37161 with the numbers of *Diatraea* larvae per acre 3·89 times that in BH. 10/12. From the samples, using all stages of *Diatraea* spp., it is seen that the actual factor between the two in this period was 3·0. In the same way from June to October there was 42·3 per cent *D. saccharalis* in the large larvae collected from B.37161, 34·8 per cent from BH. 10/12 indicating, if the numbers of the other two species remained constant, a population of *Diatraea* 1·13 times as large in B.37161 as in BH. 10/12. The observed figure here for all stages was 1·5. These two independent pairs of figures are in fair agreement, and are not incompatible with the idea that the noticeable increase in population of *Diatraea* in B.37161 above that in BH. 10/12 is due not to a general increase in the three species principally but to that of *D. saccharalis* alone.

Generations of Diatraea

In order to determine if there were any indications of peak periods of emergence of *Diatraea* during this period all small larvae obtained in the sample were recorded and it was hoped that from the proportions of small larvae: large larvae: pupae, it might be possible to see if there was any indication of distinct generations. Although there are variations in these figures throughout the sampling period there are no definite indications of any distinct generations of *Diatraea*, or even peaks of attack which could be correlated with season rather than with the stage of the cane.

PARASITISM

The larvae from each sample taken were kept in individual vials and the large larvae parasitized by *Paratheresia* were recorded. The numbers involved in the monthly total however were so small for each variety that results from all the monthly collections have been totalled and are given in *Table 10.*

Table 10

	Jan.	*Feb.*	*March*	*April*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*
Unparasitized	68	285	47	138	297	137	77	34	24	8
Parasitism	—	1	3	15	24	11	29	19	3	3
Parasitism %	0·0	0·3	6·0	9·8	7·5	7·4	27·2	35·8	11·1	27·3

These figures indicate that from a very low figure at the beginning of the growing period parasitism increased until July and August and then possibly declined, but numbers are rather small at this time and results unreliable. The figures for moth-pupae, *Agathis* cocoons and *Paratheresia* puparia found during sampling are recorded in *Table 11.*

Table 11

Sample	*Jan.*	*Feb.*	*March*	*April*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*
Moth pupae	14	58	7	13	64	14	25	9	7	2
Pupae %	66·7	47·5	25·9	28·9	40·0	50·0	46·3	37·5	36·9	50·0
Agathis *cocoons*	—	6	3	2	5	—	4	2	2	—
Cocoons %	0·0	5·0	11·1	4·4	3·1	0·0	7·4	8·3	10·5	0·0
Paratheresia *puparia*	7	58	17	30	91	14	25	13	10	2
Purparia %	33·3	47·5	63·0	66·7	56·9	50·0	46·3	54·2	52·6	50·0

The figures for *Agathis* are too small to give any worth-while comparisons and those for *Paratheresia* are probably seriously complicated by the fact that a number of puparia die and remain in the cane for a long while, and therefore the numbers of these will become additive as the season advances.

The large differences between these figures and those obtained from the larvae indicate that *Paratheresia* parasitizes principally full-grown larvae and that many 'large' larvae were removed from the field before their period of susceptibility to *Paratheresia* was finished.

Paratheresia puparia from the field were kept individually in vials in the laboratory to obtain figures for parasitism by the hyperparasite *Trichopria cubensis*, since appreciable numbers of these were obtained in 1953. Only three parasitized puparia were obtained from all samples collected in 1954. The sampling in 1953 was not as complete as in 1954 since it was only started in May and only in August were additional samples taken, in a separate area, on a quantitative basis taking definite lengths of cane row for each sample. Results comparable with those of 1954 are given in *Tables 3* and *4.*

Certain similarities and differences are seen between these figures and those for 1954 although it is unfortunate that the two sampling periods

were not the same. There are also some interesting differences between the figures for the two different sets of samples taken in 1953.

(1) Although the same tendency is seen in all sets of figures for there to be a decrease in the proportion of *Diatraea saccharalis* and an increase in that of *D. canella*, the actual percentages of each species in different fields in 1953 is different, and these figures differ from those of 1954. In the same way the proportion of *D. impersonatella* differs.

(2) Parasitism by *Paratheresia* in 1953 was higher in May and June than in 1954 but lower from July onwards.

(3) Hyperparasitism of *Paratheresia* by *Trichopria* was almost non-existent in 1954, whereas in 1953 a considerable proportion of puparia were parasitized, particularly in May and June (later in the year from September onwards percentages are based on such small numbers as to be unreliable).

(4) The numbers of borers per acre were consistently and considerably higher in 1953 (from August when quantitative records were started) than in 1954, there being four to five times as many *Diatraea* larvae and pupae present in the cane.

DISCUSSION

It is obvious from the differences between the *Diatraea* species complex in the two fields sampled in 1953 that there may be considerable differences in this regard between apparently similar fields of the same variety, but it is of interest to compare the samples taken in January 1954 in old cane with those taken from young cane of the same varieties in February 1955. The preponderance of *D. saccharalis* in the younger cane is striking.

It had been hoped in these experiments to obtain more detailed data on the variation of parasitism of *Diatraea* with season (or age of cane) and variety. Unfortunately the numbers of parasitized larvae and parasite puparia obtained in most months are too few to permit of proper analyses.

It is obvious however that, apart from the variation between individual fields, there is considerable difference between the two years. In 1953 during the period of quantitative sampling, infestation by *Diatraea* was very much heavier in this area than in 1954, and the change over from a preponderance of *D. saccharalis* to that of *D. canella* was slower and less complete in 1953. Parasitism by *Paratheresia* was highest in the earlier part of 1953, but later in 1954 it was much higher than in 1953. Hyperparasitism of *Paratheresia* was high in 1953, particularly in May and June and was virtually non-existent in 1954. This may account for the gradual decrease in parasitism by *Paratheresia* later in 1953 as compared with its increase in 1954. In turn this increase of parasitism in 1954 may be the cause of the more definite decrease later in the season in 1954 in the proportion of *Diatraea saccharalis*, the preferred host of *Paratheresia*.

Since there is some reason to believe that in Trinidad increase in *Diatraea* infestation is due largely to an increase of *D. saccharalis* alone, this less marked decrease of *D. saccharalis* later in 1953, as compared with 1954, might also be correlated with the higher overall infestation in 1953. Thus, although the data obtained with regard to parasitism are insufficient to give clear cut results, the figures give some support to the idea that the recent increase in degree of *Diatraea* infestation in Trinidad has been due largely to a

variation of the numbers of *D. saccharalis*, and that this variation is affected significantly by the action of the larval parasite *Paratheresia claripalpis*. The population of *Paratheresia* is in turn dependent on the action of the puparial parasite *Trichopria cubensis*, which was particularly common in the earlier part of 1953 as compared with 1954. It is seen that the heavier attack of *Diatraea* in 1953 may well be correlated with this greater attack by *Trichopria* on *Paratheresia*.

This sampling of sugar cane for *Diatraea* is being continued and extended in the hope that more significant data will be obtained.

(*Received January 1956*)

REFERENCE

[1] SIMMONDS, F. J. (1951). The small moth-borers of sugar cane, *Diatraea* spp., in Trinidad. *Trop. Agriculture. Trin.* **28** 80

Additional Note on the Parasites of Diatraea saccharalis *F. in the French Antilles*

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A single puparium of *Paratheresia claripalpis* Wulp., an introduced parasite of *Diatraea saccharalis* F., was found[1] at Beauport in Guadeloupe in August 1954. During a visit in January 1956 a number of puparia of this species were found associated with the remains of *Diatraea* larvae in several localities in the Beauport region. It appears that this parasite is permanently established in this area, which, with only about 40 in. of rainfall per annum, is very much drier than the native habitat of *Paratheresia* in Trinidad, and there appears to be no reason why it should not become established over the whole of Guadeloupe.

Whilst in Guadeloupe a visit was paid to the island of Marie Galante. Here the *Diatraea* parasites *Lixophaga diatraeae* Tns. and *Metagonistylum minense* Tns. were found. There is no record of these parasites ever having been liberated in the island, and it would seem that they must have been introduced in sugar cane planting material which is brought over periodically in quantity from Guadeloupe. It was stated by the managers of two plantations that borer damage now was considerably less than it was 20 years ago (before either parasite could have been present), in spite of the fact that varieties of cane now grown are very much more susceptible to *Diatraea* attack than were those planted formerly. It seems beyond doubt that this reduction in damage is attributable to the presence of these parasites.

Other *Diatraea* parasites were also seen; a single example of the larval parasite *Agathis stigmaterus* (Cress), and egg parasites *Trichogramma minutum* Riley. Other insects seen in sugar cane and not previously recorded from Marie Galante were: the yellow aphid, *Sipha flava* Forbes, and associated with it the predaceous Coccinellid, *Cycloneda sanguinea* L.; the West Indian Cane-fly, *Saccharosydne saccharivora* West., with a strepsipteran parasite, probably *Stenocranophilus quadratus* Pierce, and the predaceous Reduviid *Zelus longipes* (L.). *Saccharococcus* (*Trionymus*) *sacchari* Ckll. was common, and *Hortensia similis* Walk. was also seen.

REFERENCE

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Clonal Cuttings and Seedlings of Cocoa

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At the 1955 conference held by the Cocoa, Chocolate and Confectionery Alliance in London there were contributions (though not from West Indian delegates), which seemed to favour 'clonal seeds' (or strictly seed from selected clones), instead of cuttings as planting material for cocoa. No statistical evidence regarding the relative performances of the two types of planting material was offered and the impression was created, at least among some of the listeners, that the difference between the productivity of the two was not large, but greatly favoured seedlings in respect of cheapness and speed of propagation. Since the publication of the first results from an estate planting of both cuttings and seedlings from the same clones in Trinidad[1], additional data have accumulated and it seems appropriate to re-analyse the figures.

The field was established in 1941 chiefly as a demonstration of the two types of planting material. The material was arranged along the planting rows of the field as follows: seedling from *ICS 1, 45, 95;* cutting of *ICS 1, 45, 95* repeated three times. There were approximately 33 trees of each clone planting 'plot', making about 594 pickets or a total of two acres. The layout is obviously not ideal for statistical analysis, but is amenable and has been subjected to this treatment. The three clones represented were all considered good as cuttings at the time the plot was planted; subsequent experience has shown that *ICS 95* is generally very good, *1* sometimes good and *45* rarely so. There can therefore be little criticism of the choice of clones as particularly favouring cuttings, although the original intention was naturally to use those types that would be suitable for commercial planting. The seeds were open pollinated and obtained from an isolated one acre plot of *ICS* cuttings; there were 48 clones represented in this maternity plot but a much greater frequency of the three selected (7 to 10 per cent of the total) than of others. All three clones are capable of setting seed with their own pollen. The seed material can therefore be guaranteed clonal only for the female parent although it can be assumed that an appreciable amount of selfing has occurred. The seeds were nevertheless the purest and likely to be among the heaviest bearing that could be obtained by open pollination at the time. It is not certain that their quality can be bettered even to-day, without recourse to tedious hand pollinations to ensure legitimacy.

The plot has received routine estate treatment throughout its 13 years' life. The treatment consists of periodic cutlassing, and draining when required, but does not include the application of fertilizer. Shade trees are planted throughout the field at 27 ft. × 27 ft.; Witches' Broom is not a

serious disease and is kept under control by light pruning. The field is generally rather difficult to work, being on an exposed hillside with frequent rock outcrops.

The original planting was quite successful by estate standards and resulted in 69 per cent of the original trees surviving after three years and only 2 per cent of blank pickets. There had been virtually no casualties among the original trees in the succeeding 10 years though some have occurred among younger trees. There appears to be a considerable difference in the efficiency of establishment of various clones and planting material. *ICS 1* cuttings (90 per cent of the originals surviving) became better established than any others, and cuttings generally (72 per cent surviving) somewhat better than seedlings (66 per cent surviving). Subsequent experience elsewhere has shown that *ICS 95* cuttings are more easy to establish even than *ICS 1*, and the mediocre establishment rate of *ICS 95* (65 per cent) can only be attributed to small, weak plants due perhaps to the comparative scarcity of this clone at the time of planting. The conclusion is that well grown cuttings from vigorous clones can be more certainly established on an estate scale than seedlings; one major reason is that they are large plants when transplanted and do not depend so much on a single growing point. Had the seeds in this field been planted at stake, the mortality would no doubt have been even higher among the seedlings.

YIELD ANALYSIS

Because of the variation in casualties and the resulting variation in age of trees, the analysis of yields has been carried out on original trees only; 15 original trees were selected at random from each clonal planting material 'plot' of about 33 trees. The analysis of the data resolves itself into a double split plot, the planting material totals being split into clones and subsequently split into years. In spite of the clumsy design which allowed only one and two degrees of freedom for the planting material and its appropriate error this comparison proved significant; cuttings, over the period 3 to 13 years of age, yielded an estimated average of 1,004 lb. dry cocoa per acre per year, seedlings 540 lb. Cuttings achieved their highest yield of 1,471 lb. at seven years of age, seedlings 957 lb. at 10 years (see *Figure 1*). The importance of this difference is worth emphasizing. Assuming that the net return from harvesting and processing the additional cocoa is 30 cents a pound, the planter could have afforded to pay $5·50 more per cutting than a seedling cost him and still be as well off after 13 years from a similar field of cuttings than of seedlings; better in fact because his cuttings would still be yielding about 300 lb. more per acre ($90 net per annum) than seedlings. Alternatively, if a planter requires 200 lb. of cocoa per acre per year to cover his field maintenance costs and an additional 1,000 lb. in total per acre to recoup him for extra cost of planting operations, he would regain his initial outlay when his field was six years of age with cuttings; with seedlings he would not recover his money until the field was 10 years old.

Furthermore there is no clear evidence that these 'semi-clonal' seedlings (if they may be so termed) are superior to traditional seedling planting material. Evidence is admittedly scanty because there are now very few

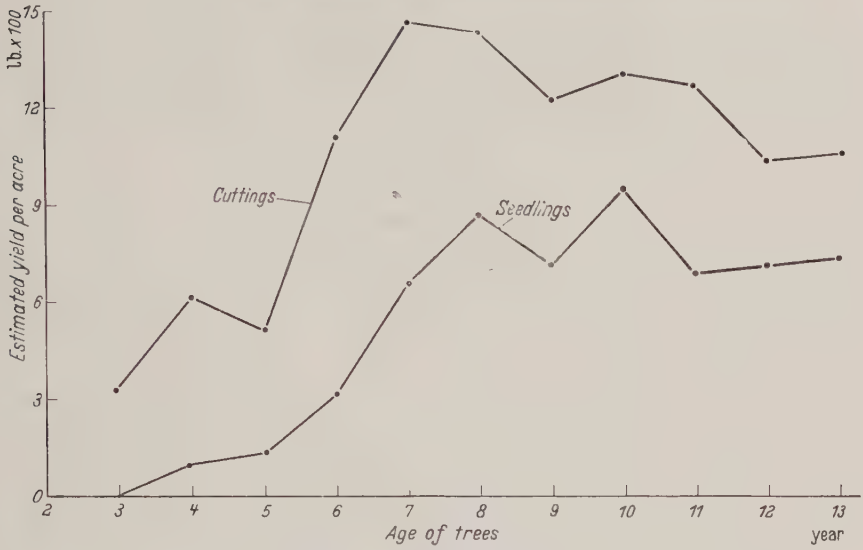

Figure 1. Yield of original trees

young seedling fields in Trinidad, but the writer has had one, which was planted in 1916, under observation for a number of years. At 20 years of age (in 1936–37 when they were first recorded) the originals in this field gave an estimated 880 lb. dry cocoa per acre. It seems from *Figure 1* by no means certain that the originals in the seedling section of the combined planting will average even 800 lb. per acre at 20 years of age.

The other significant responses that emerged from the analysis were clones, years and the interaction between age and planting material. *Table 1* records the clonal planting material yields.

Table 1. Yields of different planting material: mean yields, estimated lb. dry cacao per annum, 3 to 13 years old

Variety	*Seedlings*	*Cuttings*	*Both*
ICS 1	458	1190	824
ICS 45	635	612	623
ICS 95	526	1318	922
Mean	540	1040	723

The smallest difference that could be regarded as significant between the cells of the table is 180 lb. per acre. Thus, there is no difference between the three clonal seeds, nor between *ICS 45* as a cutting or as a seedling; *ICS 1* and *95* as cuttings are significantly heavier bearers than *ICS 45*, but they do not differ significantly from each other. This table confirms the previous observation that the 'semi-clonal' seeds are not notably different from other seedlings; although one of the female parents was significantly inferior to the other two as demonstrated by cuttings, all three types of seed show about equal performance.

The interaction between year × planting material is illustrated in *Figure 1*. The important differences between the two trends are the more rapid rate of increase in the yield of cuttings from five to seven years and the abrupt and earlier peak yield of this material. The trends of individual clones within each planting material did not differ significantly.

VARIABILITY

The data also allow an examination of the variability of cuttings compared with seedlings; this may partly explain differences in average productivity. An analysis of the variation in the 11-year total yields from tree to tree within each clone planting material cell was first made and the results are given in *Table 2*.

Table 2. Tree to tree variations within each clone planting material type

Variety	*Standard deviation of 11-year totals (lb.)*		*Coefficient of variation %*	
	Seedlings	*Cuttings*	*Seedlings*	*Cuttings*
ICS 1	13·3	15·5	79	36
ICS 45	15·4	10·5	66	47
ICS 95	16·3	12·1	85	25
Mean	15·0	12·8	76	34

The difference in the standard deviations of cuttings is less than seedlings in absolute terms, but not sufficient to be significant. When related to the total yield, cuttings are markedly less variable than seedlings. It is noticeable that the low productivity of *ICS 45* as a cutting is not due to tree to tree variability, but to the generally lower level of yield of this type compared with the other two clones. This table gives evidence that the genetic homogeneity of cuttings eliminates some of the variability from tree to tree, but with 34 per cent residual variation it is obvious that a number of other conditions influence yield under ordinary estate management.

Another aspect of yield variability is the reaction of individual trees to variations in the season. A cutting may be more productive because it is less vulnerable to seasonal climatic differences and therefore produces well in an adverse season. To make this analysis, yields were taken for each tree in one block over the age range 8 to 12 years (a period during which there was little overall trend in yields) and the within-tree variations calculated. The results are presented in *Table 3* and show that in absolute

Table 3. Seasonal variations within trees within each material type

Variety	*Standard deviation (lb. per tree per year)*		*Coefficient of variation %*	
	Seedlings	*Cuttings*	*Seedlings*	*Cuttings*
ICS 1	1·35	1·37	55	35
ICS 45	1·61	2·15	56	71
ICS 95	1·75	1·23	60	27
Mean	1·57	1·63	57	43

terms cuttings are slightly more vulnerable to the effects of seasonal changes than seedlings; in relative terms they are less so.

It is noticeable, however, that *ICS 45* as a cutting appears to be exceptionally vulnerable to seasonal differences, biennial bearing and other irregularities. This feature may account partly for its indifferent performance.

CONCLUSION

These analyses should help to bring cuttings more into perspective with clonal seedlings. On the data available cuttings appear to be decisively and economically superior to seedlings. Even with the inclusion of one cutting clone that to-day is generally not acceptable as planting material, cuttings yielded twice as much as seedlings. The two acceptable cutting clones over the age range 3 to 13 years yielded 1,250 lb. per acre a year, compared with 540 lb. for seedlings.

It is true that these ' clonal seeds ' are probably very heterozygous and do not in fact appear to be clearly superior in performance to other seed material. But it should be remembered that even at the present time no proven clonal seed exists and it is yet unknown how long it will take to produce such seed, and how good the result will be. It should also be remembered that the profitability of a cacao field depends on the marginal and not the total yield. Admittedly some countries from their natural conditions and the organization of the industry will have to rely on seedling planting material for some time to come; but in others which have limited areas of cocoa land already planted with the crop, in which communications are good and facilities exist for producing cuttings, any reversion to seedling planting must be regarded as a retrospective step.

These analyses, however, emphasize that genetic heterogeneity is not the only cause of yield variations that occur within a field. Even with the best clonal cuttings there is considerable variation from tree to tree and from year to year. This variation is evidence of the importance of other conditions, which, if they were made uniformly good throughout the field, would increase yields still further. The most obvious ones, manuring, cultivation, shading and spacing, are already under investigation in Trinidad.

(*Received April 1956*)

REFERENCE

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The Application of Foliar Analysis to Oil Palm Cultivation:

II. Uptake and Distribution of Nutrients in Mineral-Deficient Oil Palms

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In recent years, foliar analysis has been employed for the determination of the nutritional status of oil palms. As a result of this work, considerable information is available concerning the chemical composition of oil palm leaflets[1–8]. However, very little is known about the accumulation of nutrients and their distribution in other parts of the palm apart from the results obtained by Zeller[9], who analysed a single palm, and R. Wilbaux[10] who determined the chemical composition of leaves and fruit bunches.

To obtain more definite information concerning the accumulation and distribution of nutrients, the chemical analysis of the various organs of oil palms, grown in sand cultures, was carried out. The present paper deals with the results of these analyses, particularly with the following aspects:

(*a*) The total quantity of nutrients accumulated in oil palms growing under various nutrient deficient conditions

(*b*) The quantitative distribution of these nutrients in the various organs

(*c*) The question of whether organs other than leaflets, might be suitable for the diagnosis of mineral deficiencies.

METHODS

Details of the sand culture experiment have been described previously[2,5,11]. The palms were nine months old when planted in river-washed, quartz sand contained in bitumen-painted metal drums. They received approximately two litres of the appropriate nutrient solution daily. These solutions were based on the formula of E. J. Hewitt[12]. The experiment included comparisons between a complete nutrient solution and this solution with the omission of one of each of the following elements: nitrogen, phosphorus, potassium, magnesium, and calcium. After receiving the treatment for 22 months, three palms of each treatment were lifted and separated into roots, stem, spear leaves, petioles, rachids, leaflets and inflorescences. The fresh weight of each of the various parts of each palm was determined and representative bulk samples were taken and dried to enable the dry weights to be calculated. These samples were then analysed to determine the nitrogen, phosphorus, potassium, magnesium, and calcium and ash contents. The total contents of these elements in the various parts were then calculated.

RESULTS

The mass of analytical results obtained have been condensed and are presented in *Tables 1*, *2* and *3*. *Table 1* shows the average fresh weight, dry

Table 1. Growth and accumulation of elements in mineral-deficient oil palms (average of three palms per treatment)

Element	Complete treatment		—Nitrogen		—Phosphorus		—Potassium		—Calcium		—Magnesium	
	Weight g	%‡	Weight g	%	Weight g	%	Weight g	%	Weight g	%	Weight g	%
Fresh weight	13190	—	2693†	—	14265	—	9768	—	13613	—	8640*	—
Dry weight	4526	—	1079†	—	4718	—	3226*	—	4572	—	2441†	—
Ash	232·2	5·1	100·9†	9·3	107·9*	2·3	145·1	4·5	287·8	6·3	185·0	7·6
Potassium	43·6	1·0	15·5†	1·4	48·7	1·0	10·8†	0·3	51·7	1·1	31·7*	1·3
Phosphorus	9·0	0·2	2·3	0·2	6·9	0·1	7·2	0·2	9·6	0·2	5·5	0·3
Calcium	22·4	0·5	4·0*	0·4	21·0	0·4	15·4*	0·5	11·3*	0·2	18·4	0·8
Magnesium	6·5	0·1	1·5†	0·1	4·8	0·1	6·5	0·2	7·6	0·2	1·9†	0·08
Nitrogen	68·3	1·5	10·9†	1·0	64·2	1·4	60·1	1·9	72·9	1·6	30·7†	1·3

Significant difference from complete treatment: * at P = 0·05; † at P = 0·01.

‡ Percentages based on dry weight.

weight, the weight of ash and the weight of the various elements accumulated in the palms of each treatment. The distribution of these elements within the palms of the different treatments, expressed as a percentage of the total weight of the elements per palm, is given in *Table 2.*

Table 3 compares the results obtained from the analysis of samples from different parts of the palms with the results obtained from the standard method of foliar analysis, *i.e.* samples of leaflets from the first open leaf.

The 31 months old palms which received complete nutrient solution, weighed approximately 13 kg. A third of this was dry matter, whilst only 5 per cent of the dry matter remained after ashing. The total weight of the elements potassium, phosphorus, calcium and magnesium amounted to about 1 per cent of the total fresh weight and the accumulation of these elements was chiefly in the leaves, petioles and roots. There were five important treatment effects.

(1) *Nitrogen omitted*—Compared with the complete treatment palms, only a fifth of the weight of plant material was produced. The ash and potassium contents were low whilst the accumulation of the elements was highest in the roots of all three palms.

(2) *Phosphorus omitted*—No differences were found between the fresh weight of these palms and the palms which received the complete treatment. However the ash content of the palms was very low, being only 2·3 per cent compared with 5·1 per cent for the palms which received the complete treatment. The quantity of accumulated phosphorus was less than normal, but not significantly so. The magnesium content of the roots was also low. In general the results obtained did not differ greatly from the normal, and, as this appeared unusual, the sand used for the experiment was analysed. It was found that the phosphate present in the sand amounted to 80 ppm.

(3) *Potassium omitted*—The amount of plant material produced, expressed both as fresh weight and as dry weight, was low. The quantity of potassium was extremely low, and that of magnesium and nitrogen relatively high. The bulk of the accumulated elements was found in the petioles.

(4) *Calcium omitted*—Calcium deficiency was found to have no effect on the production of fresh and dry matter. However the quantity of

calcium in the palms amounted to about half the quantity in 'normal' palms.

The distribution of the elements in the calcium-deficient palms was not significantly different from that in the 'normal' palms.

Table 2. Distribution of nutrients in mineral-deficient palms expressed as percentage of total element per palm; average of three palms per treatment

Treatment	Element	Leaflets	Spears	Rachids	Petioles	Fronds	Stem	Inflor-escences	Roots
Complete	*Dry weight*	13	2	12	32	44	10	8	23
	Ash	15	3	9	22	31	6	14	31
	K	14	4	20	18	38	14	14	17
	P	13	3	11	27	38	9	11	25
	Ca	23	2	9	25	34	7	11	22
	Mg	25	4	12	25	36	5	17	13
	N	28	3	9	21	29	9	14	16
Lacking nitrogen	*Dry weight*	8*	1	9	24	33	9	—	48†
	Ash	9	2	8	17	25	8	—	57†
	K	8	2	15	25	39	5*	—	45†
	P	10	1	14	27	41	11	—	38†
	Ca	17	2	8	18	27*	7	—	48†
	Mg	15*	3	8	32	41	6	—	33†
	N	19†	2	9	16	25	9	—	48†
Lacking phosphorus	*Dry weight*	14	3	12	35	47	8	6	22
	Ash	13	3	7	19	26	5	19	33
	K	22	4	14	27	42	8	10	14
	P	16	5	13	33	46	7	9	17
	Ca	22	4	10	30	41*	7	8	18
	Mg	32	8	9	25	34	6	17	3†
	N	28	5	7	22	29	9	14	19
Lacking potassium	*Dry weight*	13	2	12	44*	56	9	1	18
	Ash	15	2	11	38*	49†	9	6	21
	K	22	4	12	32	44	17	2	11
	P	13	3	15	49	64	11	3	7†
	Ca	19	2	15	36*	51†	8	3	18
	Mg	21	3	18	43*	61†	5	3	8
	N	25	3	9	34†	43†	8	3	17
Lacking calcium	*Dry weight*	14	3	14	33	47	9	6	22
	Ash	14	3	6	28	35	6	12	34
	K	17	5	16	31	47	6*	11	19
	P	16	4	9	32	41	10	14	19
	Ca	24	4	11	27	38	9	11	17
	Mg	26	5	14	32	44	6	13	10
	N	33	5	9	18	26	10	13	17
Lacking magnesium	*Dry weight*	21†	3	18*	31	49	8	—	20
	Ash	26†	3	14*	27	42*	6	—	23
	K	29*	5	22	29	52	5*	—	13
	P	20	4	19	31	50	10	—	17
	Ca	34†	3	18*	23	41*	8	—	14*
	Mg	41†	5	23*	13	35	13	—	5*
	N	33	4	12	28	40*	10	—	12

Significant difference from complete treatment: * at P = 0·05; † at P = 0·01.

(5) *Magnesium omitted*—Magnesium deficiency resulted in a significant reduction of the weight of both fresh and dry matter. The uptake of magnesium was greatly reduced, but the quantities of potassium,

phosphorus and calcium in the palms were relatively high. The deficiency caused an accumulation of nutrients in the rachids and leaflets.

Table 3. Chemical composition of mineral-deficient palms expressed as a percentage of dry matter; average of three palms per treatment

Treatment	Element %	Sample 1st leaf	Leaflets	Spears	Rachids	Petioles	Stem	Inflorescences	Roots
Complete	K	1·93	1·02	1·94	1·60	1·03	1·21	1·62	0·71
	P	0·223	0·211	0·282	0·164	0·172	0·198	0·264	0·214
	Ca	0·662	0·887	0·602	0·419	0·373	0·380	0·646	0·475
	Mg	0·253	0·272	0·297	0·133	0·111	0·084	0·310	0·082
	N	3·39	3·25	2·27	0·95	0·97	1·43	2·61	1·10
	Ash	6·49	5·96	7·06	3·51	3·45	3·38	8·86	7·07
Lacking Nitrogen	K	2·60†	1·57	2·33	2·30*	1·50*	0·74	—	1·40†
	P	0·332*	0·292	0·201	0·313*	0·236	0·224	—	0·179
	Ca	0·491†	0·802	0·504	0·328	0·278	0·279	—	0·374
	Mg	0·305	0·316	0·311	0·116	0·189*	0·081	—	0·094
	N	1·85*	2·51	2·03	0·96	0·68	0·94	—	0·96
	Ash	10·45†	11·35†	9·85†	8·21†	6·42†	7·03*	—	11·04
Lacking phosphorus	K	2·01	1·62	1·94	1·26	0·83	1·03	1·90	0·65
	P	0·155	0·158	0·186	0·171	0·177	0·125	0·248	0·113
	Ca	0·531*	0·702*	0·661	0·393	0·402	0·395	0·737	0·354
	Mg	0·286	0·234	0·300	0·078	0·073	0·072	0·315	0·015†
	N	2·87	2·74	2·55	0·83	0·86	1·43	2·52	1·14
	Ash	6·24	6·28	7·46	4·08	3·91	4·08	12·87	10·39
Lacking potassium	K	0·68†	0·52	0·73†	0·34†	0·24†	0·61	0·48	0·22*
	P	0·295	0·225	0·431*	0·273	0·263	0·258	0·236	0·101
	Ca	0·684	0·684*	0·623	0·563	0·387	0·424	0·557	0·472
	Mg	0·337	0·316	0·316	0·299†	0·197†	0·116	0·305	0·096
	N	3·98	3·56	3·27*	1·51	1·44*	1·84	2·21	1·90*
	Ash	4·44*	5·21	5·45*	3·91	3·84	4·29	9·48	5·39
Lacking calcium	K	2·08	1·36	1·96	1·27	1·06	0·79	1·54	0·87
	P	0·177	0·200	0·301	0·142	0·217	0·236	0·265	0·182
	Ca	0·325†	0·397†	0·308†	0·196*	0·199*	0·233	0·338	0·179*
	Mg	0·318	0·288	0·254	0·175	0·156	0·102	0·275	0·061
	N	3·64	3·87	2·87	1·07	0·88	1·93	2·35	1·23
	Ash	6·82	6·10	6·93	2·96	5·50*	3·98	10·20	10·21
Lacking magnesium	K	2·20	1·66	2·11	1·76	1·24	0·84	2·49	0·90
	P	0·301	0·207	0·297	0·255	0·229	0·272	0·322	0·309
	Ca	0·839†	1·252†	0·818*	0·783†	0·577*	0·680*	0·801	0·520
	Mg	0·144	0·122†	0·103†	0·079	0·025†	0·088	0·133	0·016†
	N	3·02	2·45	1·69	0·94	1·40*	1·68	1·94	0·96
	Ash	8·14*	9·64†	7·65	6·46†	6·38†	5·97*	12·11	9·30

Significant difference from complete treatment ; * at P = 0·05 ; † at P = 0·01

DISCUSSION

The most remarkable fact revealed by this investigation is the accumulation of nutrients in specific organs, when nitrogen, potassium or magnesium are deficient. Fresh and dry matter production were greatly reduced in the case of these deficiencies. When the deficiency had no effect on growth, as in the cases of phosphorus and calcium deficiency, no accumulation of elements occurred in any particular organ.

However, the accumulation of elements in roots or petioles does not imply that the concentration of elements in other parts is low. On the contrary, the actual concentration of elements in the leaves of nitrogen-deficient palms, for example, is very high, despite the fact that the bulk of the nutrients are stored in the roots. Nitrogen deficiency causes the growth of the leaves to be reduced to such an extent, that their ash content, expressed as a percentage of dry matter, remains high. In the case of potassium deficiency, similar phenomena may be observed. Thus the bulk of the nutrients is accumulated in the petioles, but the phorphorus, calcium, magnesium and nitrogen contents of the leaves are very high, due to the reduced growth of the leaves.

The criteria, determining the suitability of a particular organ of the oil palm for analysis and diagnosis of deficiencies, are determined by:

(*a*) the number of significant differences between the chemical composition of the complete and other treatments

(*b*) the magnitude of the differences

(*c*) the sampling variation

(*d*) the technical aspect; *i.e.* some parts, such as leaflets, are easier to sample than others (roots, stems or petioles).

The greater number of significant differences of all the treatments occur in the samples of the first leaf and in the petioles. However, in some particular cases, other organs may be of value in the diagnosis of deficiencies, such as rachids for nitrogen, spear leaves for potassium and old leaves for magnesium and calcium deficiency.

There does not seem to be a single organ in which the magnitude of the differences between the complete and other treatments is consistently higher for all the deficiencies. However in some particular cases, such as potassium deficiency, the differences found in the spear leaves are generally greater than those in the youngest fully opened leaf, whilst the older leaves of magnesium deficient palms show greater differences from the complete treatment than do the younger leaves.

With regard to the sampling variation, the present data do not provide any information. All the samples which were analysed consisted of a great number of sub-samples and were thoroughly mixed, thus reducing the sampling variation as much as possible. In practice, however, the sampling variation for each organ would have to be determined separately, and a sampling technique established accordingly.

As the method of chemical analysis of plant tissues for routine practice involves the sampling of great numbers of palms, the fact that some organs are easier to sample than others may limit the latters' application. In this respect leaflets are much easier to sample than any of the other organs, and for this reason plant analysis often means in practice foliar analysis.

However, when dealing with the study of one particular deficiency, it may be of advantage to sample parts other than the leaflets of the youngest fully opened leaf. In that case, the most suitable organs to be sampled for each deficiency would be:

(*i*) for nitrogen deficiency, leaflets of the youngest fully opened leaf

(*ii*) for phosphorus deficiency, leaflets of young and old leaves

(*iii*) for potassium deficiency, spear leaves

(*iv*) for calcium deficiency, leaflets of old leaves and roots

(*v*) for magnesium deficiency, leaflets of old leaves.

Finally, it was shown that the bulk of the elements in ' normal ' palms is found in the roots, petioles and leaflets. It would thus seem incorrect from a nutritional point of view to deprive a young palm of an important part of its reserves by pruning leaves and roots, prior to transplanting, as is often done.

SUMMARY

The total fresh weight of roots, stem, inflorescences, petioles, rachids, leaflets and spear leaves of oil palms grown for two years in sand cultures, was determined. Samples were taken and analysed for dry weight, ash, nitrogen, phosphorus, potassium, calcium and magnesium contents.

It was shown that about 1 per cent of the fresh weight of 'normal' palms consists of N + P + K + Ca + Mg. With phosphorus and calcium deficiency, the distribution of the elements in the palms was not significantly different from the 'normal' treatment.

When nitrogen was deficient, nutrients accumulated in the roots, whilst potassium deficiency caused an accumulation in the petioles. In the case of magnesium deficiency, an accumulation was found chiefly in the leaflets and rachids.

For the diagnosis of mineral deficiencies, leaflets of the youngest fully opened leaf and the petioles showed the greatest number of significant differences between the complete and other treatments and, therefore, may be considered 'suitable' organs for analysis.

ACKNOWLEDGEMENT

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Book Reviews

IBAN AGRICULTURE: COLONIAL RESEARCH STUDIES No. 18

J. D. Freeman, Her Majesty's Stationery Office, London, 1955. 148 *pp.* (illus.) 12*s* 6*d*

So little published information is available on the agriculture of the British Borneo territories that any addition is particularly welcome. The Iban are the largest single racial group in Sarawak. Dr Freeman is an anthropologist, but has written an account of Iban agriculture with which, so far as it goes, agricultural scientists will not wish to quarrel. The system of farming here presented is in fact the central problem for the agricultural authorities in Sarawak.

The Iban and other local peoples live by felling the forest on steeply sloping land in order to take one or two crops of upland rice which leave the soil in an eroded and degraded condition. It was not the business of this research project to discuss in any detail the remedial measures which are necessary. The author presents a picture of a state of affairs which will eventually have to be eliminated. This objective study of present conditions will both help to emphasize their dangerous trend and assist those who aspire to remedy them with the people's cooperation.—G.B.M.

WORLD CATALOGUE OF GENETIC STOCKS. RICE. SUPPLEMENT No. 5

Food and Agriculture Organisation of the United Nations: Paris, 1955. 13 + vi *pp.* (illus.) 1*s* 3*d*

Those engaged in rice breeding will find the fifth supplement a useful compendium of up-to-date knowledge of various characters of rice stocks maintained in India, Malaya, the Philippines, Formosa and the Gold Coast. The information is conveniently presented in tabular form, enabling the reader to obtain at a glance (*1*) all the available information on any one genetic stock and (*2*) an identification of genetic stocks possessing a particular character. Cross reference lists of stocks are also given, indicating the country of origin, local code numbers and the stations where the stocks are maintained.—F.W.C.

BREEDING BEEF CATTLE FOR UNFAVOURABLE ENVIRONMENTS

A. O. Rhoad (Ed.). University of Texas Press: Austin, Texas. 1955. 248 *pp.* (illus.) $4.75

In October 1953 there occurred an important event in the annals of tropical livestock development. In order to celebrate the one hundredth year of successful operations R. J. Kleberg Jr, the President and General

Manager of the King Ranch, assembled at Kingsville, Texas a large group of cattle raisers and applied scientists from all over the world. This gathering was unique in that it brought together for the first time practical people genuinely interested in animal production in the warmer areas of the world. The proceedings of this meeting have now been published and make refreshing reading since, unlike the proceedings of so many of our post-war livestock gatherings which list a large number of theoretical resolutions, the reader is treated to a readable collection of technical papers describing what has already been achieved and how it is proposed to embark upon further improvements.

The proceedings have been ably edited by the geneticist at the King Ranch, who is internationally known for his contributions to tropical animal production. The format is excellent and includes colour and monotone illustrations and figures. The symposium was divided into two parts, one part dealing with the unfavourable environment and the other with the breeding of cattle suitable for the unfavourable environment.

Amongst the contributors are J. Bonsma, well known for his work in South Africa, D. Lee who discusses heat tolerance, J. Hammond who talks about climate in relation to reproduction, and many well known North American workers who, in relation to hot climate animal production, cover a variety of subjects including animal health, planes of nutrition, soil fertility and the breeding of range grasses. The genetic aspects of cattle production in hot climates are discussed by J. L. Lush, L. M. Winters and E. J. Warwick, all internationally known for their work in this field. The carcass quality as measured before and after slaughter, and the noteworthy achievements of the Sao Paulo group with Zebu cattle in Brazil are subjects which are also included. The symposium is ably rounded off with a paper from A. O. Rhoad on the Santa Gertrudis breed of beef cattle.

This book represents the distilled essence of the work and experience to date of several internationally known workers, and is a review which should be read by all those in the tropics who have even the remotest contact with animal production.—J.R.H.

KNOW YOUR TRACTOR

Shell Petroleum Company Limited: London, 1955. 356 *pp.* (illus.)

Like so many of the oil company publications this weighty and useful guide is excellently produced and lavishly illustrated. Photographs show tractors at work in the tropics and elsewhere, whilst drawings in the text illustrate the operation of tractor components very clearly. There are useful sections on lubrication, fuels, and the storage and handling of fuels and lubricants.—J.E.M.

SHIFTING CULTIVATION IN AFRICA: THE ZANDE SYSTEM OF AGRICULTURE

P. de Schlippe. Routledge & Kegan Paul, 1956. 304 *pp.* (illus.) 42*s*

The author emphasizes that, while this is a case-study of shifting cultivation by one tribe in the southern Sudan, the methods and conclusions are

applicable to wide areas in Africa. Most of the factual matter is derived from a detailed survey in 1948–50. The methods employed are not particularly original, and in fact might have gained from comparison with modern statistical methods employed in agricultural surveys elsewhere in Africa. What is unusual is the long period of detailed observation, not only during the survey but for some years before and after by the author, who is an agronomist of long experience in the Belgian Congo as well as the Sudan.

Mr de Schlippe stresses the fact that Zande agriculture consists not in crop rotations but in different field types. This point has been made before for African peasant societies, for example in the ' mitalla surveys ' published in Uganda in 1938, but never so lucidly expounded with such a wealth of observation. The author's social and anthropological interests make his views on the problems, and the possible directions, of change in the existing farming system, which are expressed in the later part of the book, of great interest. He is a thoughtful person and a persuasive writer.

The book may become a minor classic of its type, and might well be made required reading for students approaching the general problems of African peasant agriculture. It will be a pity if it is not widely read because it refers only to a single tribe. The problems dealt with can be met in many territories.—G.B.M.

SUGAR-CANE AND ITS DISEASES

C. W. Edgerton, Louisiana State University Press: Baton Rouge, 1955. 290 *pp.* (illus.) $5.00

The author is one of the foremost American contributors to the literature on sugar-cane pathology. The present publication is the third of the Biological Science Series of Louisiana State University Studies and is a revision of lectures, reviews, abstracts, *etc* prepared over a period of more than 20 years of teaching sugar-cane pathology at the University.

Part I is devoted to general aspects of sugar-cane, its history, structure, classification and breeding.

Part II, concerned with cane pathology proper, is divided into chapters on stalk rots and leaf lesions of fungal origin, smut, mildews, bacterial diseases, virus diseases, root rots and three small chapters covering the various odds and ends of multiple-buds, injuries, angiosperm parasites, *etc.* Not unnaturally, the author's favourite cane diseases receive pride of place; Red Rot occupies no less than 20 pages whereas Chlorotic Streak and Ratoon Stunting Disease are each somewhat summarily dismissed.

Each important disease is examined under the usual headings of distribution, history, symptoms, etiology, importance and control measures; there is usually a section on varietal resistance.

From the teaching point of view, the book would have been much enhanced by the inclusion of line drawings in the text, especially diagrams of the fungus fructifications and spores. The illustrations consist of a solid tail-piece of 39 figures, all, except one graph, photographs or composite photographs.—P.B.H.

THE SOUTH AFRICAN SUGAR YEAR BOOK

Compiled by the Staff of the South African Sugar Journal. The South African Sugar Journal: Durban, 1956. 239 *pp.* (illus.) 10*s*

The high standard achieved in previous numbers of this publication has been maintained and the scope of information provided increased by the addition of special articles by such recognized authorities as A. C. Barnes and P. Honig. The book provides comprehensive information relative to the sugar industry of South Africa covering in considerable detail the research programme, advisory services, statistics relative to acreages, yields, factory out-turn, sugar cane varieties and information on pests and diseases.

A directory is given of all sugar estates in the countries of South, East and Central Africa including British, Portuguese, and Belgian enterprises. Mauritius estates are aso included. The manufacturers' and suppliers' section provides most useful information relative to the firms listed and the commodities and/or services offered.

The book is well illustrated by charts, tables and excellent plain and colour photographs. This is a valuable book of reference for general information and statistics relative to the South African sugar industry.—W.J.B.

OBITUARY

HARRY VINCENT MERCER METIVIER, O.B.E., I.S.O., B.Sc., M.R.C.V.S.

Harry Metivier's sudden death on 20 February 1956 came as a great shock to his many friends in Trinidad and to the College with which he had for so long been associated. He was for many years a member of the staff of the Department of Agriculture of Trinidad & Tobago from which he retired, in 1952, holding the post of Deputy Director of Agriculture (Animal Husbandry). As far back as 1923 he undertook, on a part-time basis, the work of teaching Veterinary Science at the College, work which he continued, without a break, until the day of his death.

Many generations of past students of the College will remember Harry Metivier with affection; quiet and unassuming in manner, he never spared himself in his work and it was characteristic of him that he was in harness to the end.

To his wife, Sylvia, to his son and daughter and to his family we offer our sincere sympathy in their grievous loss.

Recent Publications of The Imperial College of Tropical Agriculture

Studies in West Indian Soils, XII: The Agricultural and Forest Soils of St. Lucia, by F. HARDY and G. RODRIGUES. 5*s*

Studies in West Indian Soils, XIII: The Agricultural Soils of St. Kitts-Nevis with Notes on Statia (Dutch), by F. HARDY and G. RODRIGUES. 5*s*

A Report on Cacao Research, 1945–1951. 132 *pp.* fully illustrated in colour and black and white. 25*s*

A Report on Cacao Research, 1952. 8*s*

A Report on Cacao Research, 1953. 10*s* 6*d*

A Report on Cacao Research, 1954. 12*s* 6*d*

Reprints are available, at varying prices, of articles in the Cacao Research Reports, including the Colour-Illustrated Guide to the Diagnosis of Mineral Deficiencies in Cacao (1945–1951 Report)—Price 5*s* plus postage.

Memoirs—Economic Series No. 2: Peasant Farming: Report on Peasant Experimental Farms at the Imperial College of Tropical Agriculture, Trinidad, B.W.I., by A. L. JOLLY. 1*s*

Flora of Trinidad and Tobago: This Flora, which has been issued irregularly in parts since 1928, is a compilation of the work of many authors. The early parts, mainly by R. O. WILLIAMS, were edited by the Department of Agriculture of Trinidad and Tobago, but since the end of the second world war editing has been taken over by the Botany Department of the Imperial College. The Flora may be obtained either from the Department of Agriculture or from the Imperial College. The following parts have been published :

Volume I Ranunculaceae to Araliaceae complete in eight parts and index. 26*s* 6*d*

Volume II Part 1. Rubiales. 2*s*

Part 2. Asterales to Primulales. 3*s* 6*d*

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Part 5. Scrophulariaceae to Acanthaceae. 5*s*

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Further parts are in preparation.

These and other publications can be obtained from the Library and Publications Department, Imperial College of Tropical Agriculture, Trinidad.

NEW BOOKS

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Edited by R. L. WAIN and F. WIGHTMAN, *Proceedings of a Symposium held at Wye College (University of London) July* 1955

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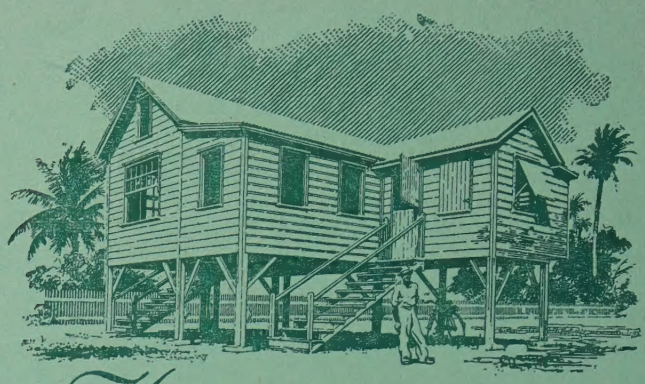

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